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Final Report
Space Transportation Systems Technologies

Milestone Deliverable
Contract NAS8-99060

September 30, 2001

Prepared for

Space Transportation Directorate
George C. Marshall Space Flight Center
National Aeronautics and Space Administration

SAIC
An Employee-Owned Company

NRA 8-21 Contract NAS8-99060
Space Transportation Systems Technologies
Final Report

FOREWORD

This document is the final report by the Science Applications International Corporation (SAIC) on contracted support provided to the National Aeronautics and Space Administration (NASA) under Contract NAS8-99060, "Space Transportation Systems Technologies". This contract, initiated by NASA's Marshall Space Flight Center (MSFC) on February 8, 1999, was focused on space systems technologies that directly support NASA's space flight goals. It was awarded as a Cost-Plus-Incentive-Fee (CPIF) contract to SAIC, following a competitive procurement via NASA Research Announcement, NRA 8-21. This NRA was specifically focused on tasks related to Reusable Launch Vehicles (RLVs). Through Task Area 3 (TA-3), "Other Related Technology" of this NRA contract, SAIC extensively supported the Space Transportation Directorate of MSFC in effectively directing, integrating, and setting its mission, operations, and safety priorities for future RLV-focused space flight. This final report summarizes the support provided by SAIC to the Space Transportation Directorate, NASA/MSFC.

NRA 8-21 Contract NAS8-99060
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TABLE OF CONTENTS

FOREWORD.....	<i>i</i>
TABLE OF CONTENTS.....	<i>ii</i>
INTRODUCTION AND BACKGROUND	<i>1</i>
SCHEDULE FOR BASE AND OPTION YEARS	<i>3</i>
OBJECTIVES AND ACCOMPLISHMENTS vs WBS ELEMENTS.....	<i>4</i>
2.0 Technology Assessment	
2.1 Technology Assessment Tools	
2.1.1 Internet Accessible TIPS.....	5
2.1.3 TIO Database System.....	8
2.1.4 Technology Benchmarking.....	10
2.2 Technology Prioritization	
2.2.1 Bantam Technology Prioritization	11
2.2.1.1 Spaceliner Technology Prioritization (SPST)	13
2.2.2 Reusable Systems Technology Prioritization.....	15
2.2.3 Exploration Technologies Assessment.....	18
2.2.4 Future X (Second Gen) Technology Prioritization.....	20
2.2.4.1 Second Gen RLV Technology Prioritization (SPST-II).....	23
3.0 Information Technologies	
3.1 Technology Database & Information System Development	
3.1.1 Technologies Database Development.....	24
3.1.1.1 NASA X-37 Public Relations CD-ROM (Media Fusion)....	29
3.1.1.2 Space Transportation CD-ROM, Phase II (EMI).....	30
3.1.1.2 Space Transportation CD-ROM, Microgravity (EMI).....	31
3.1.1.3 ISE Support for Reusable Space Transportation System.....	32
3.1.1.4 Second Generation RLV Program Database.....	34
3.1.7 Space Transportation CD-ROM, Phase II (EMI).....	35
4.0 Integrated Design and Engineering	
4.1 Integrated Design and Engineering	
4.1.1 Identify Tools and Techniques.....	36
4.1.2 Technology Evaluation and Analysis.....	38
4.1.2.1 Future X/Pathfinder Program Plans.....	45
4.1.2.2 Future X/Pathfinder Technology Specialist (X-37).....	46

NRA 8-21 Contract NAS8-99060
Space Transportation Systems Technologies
Final Report

OBJECTIVES AND ACCOMPLISHMENTS vs WBS ELEMENTS (Continued)

4.1.2.1	Future X/Pathfinder Program Plans	45
4.1.2.2	Future X/Pathfinder Technologies Specialist (X-37).....	46
4.1.2.3	Fastrac (MC-1) SRD, Engine, Components Verification	49
4.1.2.4	RFS Technologies Specialist.....	52
4.1.2.5	Future X/Pathfinder Technology Specialist (X-34).....	53
4.1.2.6	Combined Cycle Propulsion Database (CCPD).....	55
4.1.2.7	Dev. of S/W Tool for Rapid Evaluation of RLVs (DESE)...	58
4.1.6	Space Transportation Resources (STR) Database.....	59
4.1.7	Pathfinder LV Des. Charac. & Graphics (Media Fusion).....	62
4.2	Systems Visualization	
4.2.1	Flight Coverage.....	64
4.2.3	John Frassanito & Associates (Subcontract).....	68

<i>CONCLUDING COMMENTS.....</i>	<i>70</i>
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<i>REPORT DOCUMENTATION PAGE (Standard Form 298).....</i>	<i>71</i>
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NRA 8-21 Contract NAS8-99060
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Final Report

INTRODUCTION AND BACKGROUND

Contract NAS8-99060, "Space Transportation Systems Technologies", was focused on space systems technologies that directly support NASA's space flight goals. Through this contract, SAIC's assistance enabled the Space Transportation Directorate of MSFC to more effectively direct and synergistically integrate the Reusable Launch Vehicle (RLV) focused program. This effort included overall systems engineering, development and implementation of technology assessment tools, collaborative technology evaluation techniques, advanced data collection, search and retrieval systems, vehicle cost and economic assessment tools, system visualization processes and specialized independent assessment of launch vehicle concepts. SAIC directly supported NASA's across-the-board Space Transportation Architecture Studies (STAS) conducted to enable definition of the nation's space flight development plans for the next several decades. In supporting the STAS studies, SAIC was closely associated with the MSFC in its systems and cost analyses of candidate RLV systems that were advanced by numerous hardware-producing contractors. SAIC developed an innovative space technology investment prioritization process and associated decision support software. Using this process SAIC effected the technology assessment support provided by the Space Propulsion Synergy Team (SPST). SAIC provided expert consultative support to NASA's X-34 and X-37 development activities. SAIC supported the verification and validation activities associated with the FASTRAC/MC-1 engine development and led the development of high-resolution visual simulations of the planned X-33 demonstration flights. Through evolved efforts under this contract, SAIC has provided support to NASA's Strategic Launch Initiative (SLI) in the areas of overall systems engineering, and safety and risk assessment.

SAIC used a skill mix of specialists in the areas of systems engineering, design/development, verification/validation, mission support, safety/risk assessment, and project management to accomplish the objectives of this contract. SAIC has had 12 subcontracts supporting this activity. SAIC, as the prime contractor, does not build hardware and therefore had no conflicts of interest.

OBJECTIVES AND ACCOMPLISHMENTS

Following an initially contracted Base Year (February 8, 1999 through September 30, 1999), two option years were added to the contract. These were Option Year 1 (October 1, 1999 through September 30, 2000) and Option Year 2 (October 1, 2000 through September 30, 2001). This report summarizes SAIC's accomplishments for the Base Year, Option Year 1, and Option Year 2.

The Work Breakdown Structure (WBS) for this contract was organized into three primary task areas corresponding to the Statement of Work (SOW) as follows:

- 1.0 (Not applicable to the contracted SOW tasks)
- 2.0 Technology Assessment
- 3.0 Information Technologies
- 4.0 Integrated Design and Engineering Technologies

The schedule and comprehensive WBS list of tasks that evolved under each of the three primary task areas during the Base Year and Option Year periods of the contract are represented in **Figure 1**. Each of the tasks listed in Figure 1 is individually and sequentially addressed in the following pages in terms of "Statement of Work" and "Task Results".

The original Statement of Work (SOW) text for each task, and subsequent additions and modifications to the SOW, are given for ease of reference. The requirements of each SOW task were fulfilled during the contracted periods of performance for this contract.

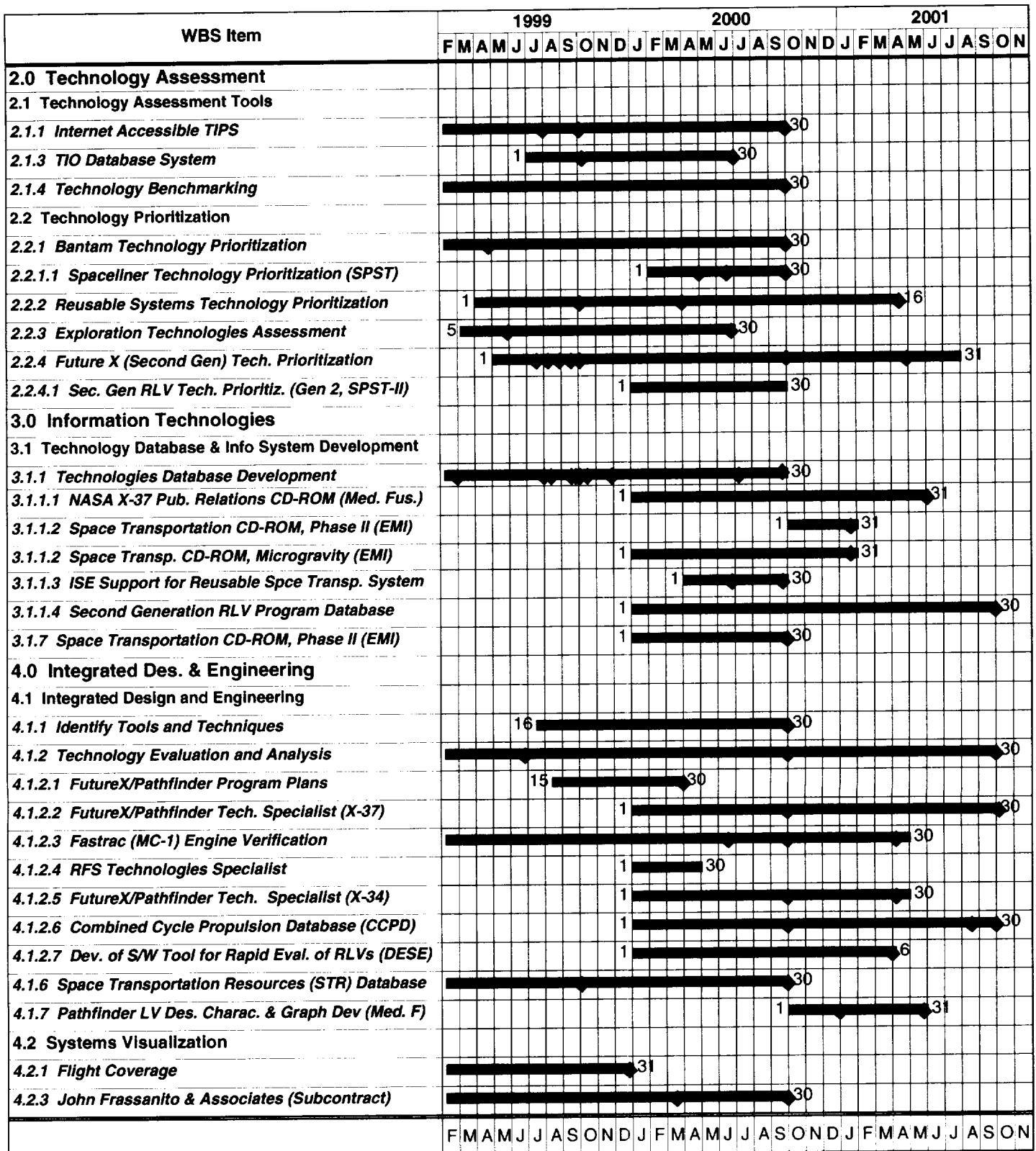
The Task Results are overviewed in the following pages for each individual WBS task in terms of the *Summary*, *Key Items as reported in Monthly Progress Reports*, and the *Reports/Deliverables*.

The Summary paragraph(s) for each task represent an overview of the contract results. In general, the Summary reflects task accomplishments that have been reported more fully in the Monthly Progress Reports and the specific task reports/deliverables required for each task.

The Key Items for each task are directly extracted from Form 298, Item 13 of the Monthly Progress Reports (MPRs), and are listed with the respective MPR delivery dates under the appropriate period of performance. These "monthly" progress reports, of which there were thirty-four during the course of the contract, were submitted on four-week intervals. This reporting schedule resulted in thirteen technical progress reports during each year of the contract and permitted SAIC to summarize its resource expenditures in consonance with its internal accounting closeout dates. The listings of Key Items from the MPRs are presented in this report to give a sense of the time-related events, and the progress that was made during the performance of the individual tasks.

The third element of Task Results for each individual task is a listing of the Reports/Deliverables. These reports/deliverables were submitted in accordance with contract requirements and, along with the Monthly Progress Reports, provide a comprehensive account of the accomplishments related to this task. The reader is referred to these documents if greater detail/depth is desired.

Figure 1: NRA 8-21 Contract NAS8-99060 - Base & Option Years 1 & 2 Schedule



OBJECTIVES AND ACCOMPLISHMENTS

VS

CONTRACTED WORK BREAKDOWN STRUCTURE (WBS) ELEMENTS

Work Breakdown Structure (WBS) Elements

2.0 Technology Assessment

2.1 Technology Assessment Tools

2.1.1 Internet Accessible TIPS

Statement of Work

The contractor shall define, develop, and demonstrate a software environment for the Technology Investment Prioritization System (TIPS) necessary to facilitate the utilization of the prioritization process in a distributed mode by multiple participants. The definition and demonstration of the distributed mode TIPS shall be accomplished under this task. The software development shall be done under WBS 3.1.1. The TIPS software shall be migrated to a web site for use via the Internet in a distributed mode. Exercises shall be planned and used to test and validate the Internet-based TIPS. The TIPS database environment software and associated Internet-accessibility software shall be populated with representative Technology Investment Opportunity (TIO) data, and demonstrated to NASA. The demonstration of the Internet accessible TIPS and process documentation will be the primary deliverables under this task. (Basic)

SAIC shall continue to develop an Internet accessible software environment for the Technology Investment Prioritization System (TIPS) necessary to facilitate the utilization of the collaborative space transportation prioritization process in a distributed mode by multiple participants. The TIPS software shall be migrated to a web site for use via the Internet in a distributed mode. Exercises shall be planned and used to test and validate the Internet-based TIPS (ITIPS). (Mod 7)

Task Results

Summary:

SAIC used a collaborative process for the prioritization of candidate technology investments. It was based on using the well-documented Analytic Hierarchy Process (AHP). An analytic hierarchy of technology evaluation was collaboratively defined and weighted. Quantitative and qualitative information was provided on each candidate technology. Comparisons were made between candidate technologies for each criterion and by each evaluator.

The process was supported by the Technology Investment Prioritization System (TIPS)... a relational database developed in Microsoft Access. TIPS was used in several workshops to assist NASA in prioritizing technologies.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Initiated development of an Internet Accessible version of the Technology Investment Prioritization System (TIPS) software tool. (3/5/99)

- Participated in the NASA-led Space Propulsion Synergy Team's In-Space Propulsion technology prioritization effort to support NASA's FY2000 budget planning. (3/5/99)
- Continued development of an Internet Accessible version of the Technology Investment Prioritization System (TIPS) software tool. New IT Zone server being installed at SAIC. (4/2/99)
- SAIC facilitated the In-Space Propulsion (ISP) Technologies Prioritization Workshop at the SAIC facility in McLean, Virginia during April 19-22, 1999. At this workshop, Dr. Odom led prioritization activities in which a candidate set of ISP technologies was prioritized into five mission application categories. (4/30/99)
- Effort continued toward implementation of an Internet accessible version of the TIPS S/W tool for collaborative support of space transportation technology decision-making. (5/28/99)
- Continuing work on Internet accessible version of the TIPS S/W tool enabled evaluators at distributed remote sites to input to prioritization of candidate technologies. (6/25/99)
- Review and demonstration of the initial Internet-accessible TIPS scheduled for July 28 at SAIC facilities. Part of the incentivized deliverable due on July 31. (7/23/99)
- Reviewed and demonstrated initial Internet-accessible TIPS at the SAIC facilities on July 28, 1999. (8/20/99)
- Drafted Two white papers for MSFC review: (1) "A preliminary Plan for Space Transportation Directorate Support", & (2) "A Process for Using the MSFC Collaborative Engineering Center in support of the Space Transportation Directorate". (8/20/99)
- Worked with NASA B Team for the STAS99.3 effort for facilitation of the prioritization of candidate technologies to support a 2005 decision on RLV program. (8/20/99)
- TIPS software was used to support SAIC's facilitation of prioritization of candidate technology investments as part of the NASA's STAS Phase III effort. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Installing previous version of ITIPS on a new server that is accessible outside our firewall running IIS (Internet Information Server). Configuring for secure access. (11/26/99)
- Continued installation and test of the Internet accessible version of the Technology Investment Prioritization System (ITIPS) on a new external server. Process is underway to add new features derived from a series of four earlier STAS-related workshops. (12/24/99)
- Planning initiated to prepare the ITIPS software for use in facilitating the national Space Propulsion Synergy Team (SPST) workshop. Four other workshops are planned. (1/21/00)
- Changes needed in the MSFC Collaborative Center (CEC) to speed up the computer network have been specified to NASA. Working to add reporting/other features. (2/18/00)

- Investigated methods to automate the white paper process using TIPS. Conducted a meeting to explain the use of TIPS and the prioritization process to Technology Working Group Leads for the Spaceliner 100 Workshops planned for April. (3/17/00)
- SAIC used the TIPS software to facilitate the NASA Operations and Range Technology Working Group (TWG) Spaceliner 100 Technologies Prioritization Workshop, April 17-18, 2000. The purpose was to produce data to support NASA's budget planning. (5/12/00)
- Preparing the Internet Accessible version of TIPS (ITIPS) for use in facilitating the planned Human Exploration Propulsion Technologies Prioritization Workshop. (6/9/00)
- Preparations continued on the Internet Accessible version of TIPS (ITIPS) for use in facilitating the planned Human Exploration Propulsion Technologies Prioritization Workshop. (7/7/00)
- Documented the Internet Accessible version of TIPS (ITIPS) used in facilitating the August 16/17 Human Exploration Propulsion Technologies Prioritization Workshop. Technology investment opportunity database development is continuing. (2/29/00)

Reports/Deliverables:

Technical Report: "Operational Software Demonstration Report" (WBS 2.1.1, Internet Accessible TIPS), July 31, 1999.

Technical Report: "Operational Software Demonstration Report" (WBS 2.1.1, Internet Accessible TIPS), September 30, 1999.

Technical Report: "Operational Software Demonstration Report" (WBS 2.1.1, Internet Accessible TIPS), September 30, 2000.

2.0 Technology Assessment

2.1 Technology Assessment Tools

2.1.3 TIO Database System

Statement of Work

The contractor shall use the preliminary design for an electronic Technology Investment Opportunity (TIO) database system briefed to the NASA Systems Working Group in December 1997, to produce an operational database system tool for use by the Space Transportation Programs Office in facilitating the development of technology investment portfolios. The database requirements and final design shall be established under this task. The software development shall be done under WBS 3.1.1. The system shall be Internet-based and shall be demonstrated using sample technology data to be supplied by NASA. The demonstration of the operational TIO database system and associated process documentation will be the key deliverables as a result of this effort. (Basic)

The contractor shall maintain and extend the Technology Investment Opportunity (TIO) database system as needed to support facilitation of the prioritization of technology investments for the Space Transportation Directorate. (Mod 7)

Task Results

Summary:

SAIC developed a collaborative process for the prioritization of candidate technology investments for the MSFC Space Transportation Directorate. This process is supported by a Technology Investment Prioritization System (TIPS) facilitation software tool that has been successfully used in several technology prioritization workshops. As part of the prioritization process, white papers describing the technologies were prepared. In order to standardize the process, SAIC developed the TIO database software tool. Information about the technologies was entered into the TIO database. In 1998, SAIC facilitated the initial demonstration of the Technology Investment Prioritization process at NASA Langley. In April 1999, SAIC facilitated the national In-Space Propulsion (ISP) Technologies Prioritization Workshops. Later, in August 1999 SAIC facilitated five workshops for the Space Transportation Architecture Studies (STAS). The objectives of this task were to demonstrate the functionality and use of the TIO database and its integration with TIPS, demonstrate entering and retrieving data from the TIO database, and demonstrate use of TIPS with integrated display of data from the TIO database. These objectives were accomplished.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Prototype Technology Investment Opportunity (TIO) database implemented via Access database software. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Briefed availability/capability of the Internet Accessible Technology Prioritization System to the Space Propulsion Synergy Team, in conjunction with Space Transportation Day. Also discussed the prototype Technology Investment Opportunity (TIO) Database. (10/29/99)
- Improved TIO Database System and focused on creating a web user interface. Worked on integration of a TIO Database version for Spaceliner 100 technology white papers in preparation for facilitation of workshop to prioritize candidate RLV technologies (11/26/99)
- Using ITIPS software, continued integration of a version of the TIO Database customized for Spaceliner 100 technology white papers. (12/24/99)
- Work continued on integration of a version of the TIO Database, customized for Spaceliner 100 technology white papers, with ITIPS software. Website planned. (1/21/00)
- Initiated effort to integrate use of a Technology Investment Opportunity (TIO) Database System into the SAIC Technology Investment Prioritization System (TIPS). (5/12/00)
- A demonstration of a Technology Investment Opportunity (TIO) Database System was prepared. This system could replace the current white paper process. (6/9/00)

Reports/Deliverables:

“TIO Database System Report” (WBS 2.1.3, TIO Database System Demonstration)
October 8, 1999; June 30, 2000.

2.0 Technology Assessment

2.1 Technology Assessment Tools

2.1.4 Technology Benchmarking

Statement of Work

The contractor shall define a process and a database system for the Advanced Space Transportation Program Office to use in establishing and maintaining technology benchmarks relevant to its program needs. The data should benchmark the current and projected levels of technology development from all sources including industry, small business, academia, and government laboratories. The database software shall be developed under WBS 3.1.1. The deliverables under this task will be a demonstration of the Technology Benchmarking database and the documented process for using and maintaining it. (Basic) (Deleted in Mod 7)

Accomplishments

Summary:

SAIC developed a plan for establishing a technology benchmarking process for the Advanced Space Transportation Programs Office. Provided a white paper to NASA that summarized a tailored approach to Space Transportation Technologies Benchmarking Database System.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Produced a draft plan for establishing a technology benchmarking process for the Advanced Space Transportation Programs Office. (3/5/99)
- Reviewed current definition of a prototype Technology Investment Opportunity Database for application to a technology benchmarking process for the ASTP Office. (4/2/99)
- Initiated investigation of web site resources for technology benchmarking. (5/28/99)
- A white paper summarizing a tailored approach to establishing a Space Transportation Technologies Benchmarking Database System was prepared and delivered to NASA. (6/25/99)
- White paper summarizing a tailored approach to Space Transportation Technologies Benchmarking Database System was prepared and delivered to NASA. (7/23/99)

Reports/Deliverables:

Technical Report, "Technology Benchmarking" (WBS 2.1.4, Technology Benchmarking) September 30, 1999.

2.0 Technology Assessment

2.2 Technology Prioritization

2.2.1 Bantam Technology Prioritization

Statement of Work

The contractor shall coordinate with MSFC in planning and facilitating the prioritization of candidate technology investments for the Bantam Program of the Space Transportation Program Office (*Directorate*). The prioritization process will use the capabilities of the MSFC Collaborative Engineering Center (CEC) as it becomes available, to establish data, *including safety and risk assessments*, for the comparison of the benefits of candidate technologies. The results of each prioritization cycle shall be documented in a briefing and a final report. Deliverables will include a completion of the annual facilitation and documentation of priorities for Bantam (*Spaceliner*) technologies. (*Mod 7*)

Task Results

Summary:

Developed procedures and software for the facilitation of workshops to prioritize candidate sets of technologies. Developed a Bantam Technology Prioritization Report and documented In-Space Propulsion (ISP) Technologies Prioritization workshop. Worked with the national Space Propulsion Synergy Team (SPST) to support NASA in prioritizing Spaceliner 100 technology investments. Prepared and mailed out a detailed orientation package to all technical and programmatic evaluators for the propulsion technologies prioritization workshop. Prepared and used TIPS software to support a series of five back-to-back Spaceliner 100 Technologies Workshops. These were facilitated by SAIC in the MSFC Collaborative Engineering Center. The Workshops were conducted during the month of April, 2000. SAIC continued to work with the National Space Propulsion Synergy Team (SPST) in follow-up to the Spaceliner 100 Workshop.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Participated in planning discussions with MSFC to explore requirements and ideas for the facilitation of Bantam technology prioritization. (3/5/99)
- Procedures and software being developed for the facilitation of workshops to prioritize candidate sets of technologies. Briefing to the Operations Cost Model Steering Committee. (4/2/99)
- A Bantam Technology Prioritization Report was prepared as a key milestone deliverable during this reporting period. The report and Form DD 250 were delivered on 4-30-99. (4/30/99)
- Documented In-Space Propulsion (ISP) Technologies Prioritization Workshop results via a set of 94 charts. Results reviewed via national SPST telecon and electronically transmitted to the NASA Steering Committee for input to FY2001 budget process. (5/28/99)

- A second white paper was written and provided as a basis for setting up a task team to establish and demonstrate the initial CEC capability at MSFC. A third white paper was provided as a first cut at a systematic approach to ongoing use/improvement of the CEC. (6/25/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Worked with the national Space Propulsion Synergy Team (SPST) to support NASA in prioritizing Spaceliner 100 technology investments. Supported evaluation inputs. (11/26/99)
- Continued work with the Space Propulsion Synergy Team (SPST) to plan for and facilitate the assessment and prioritization of candidate propulsion technologies for potential application to Spaceliner class systems. (12/24/99)
- Work continues on plan for prioritization of candidate propulsion technologies for potential application to Third Generation RLV's or Spaceliner 100 class systems. (1/21/00)
- Changes needed in the MSFC Collaborative Center (CEC) to speed up the computer network have been specified to NASA. Working to add reporting/other features. (2/18/00)
- Continued coordination with the national Space Propulsion Synergy Team (SPST) through telecons to plan for their workshop to prioritize candidate Spaceliner technologies. Technology advocates are preparing representative white papers. (2/18/00)
- Workshop held with representatives of ASTP at SAIC to discuss requirements for the system engineering process and software to support the long term process. (2/18/00)
- Detailed orientation package was prepared and emailed out to all technical and programmatic evaluators for the propulsion technologies prioritization workshop. (3/17/00)
- Focused efforts on final preparation and use of TIPS software to support the series of five back-to-back Spaceliner 100 Technologies Workshops. These were facilitated by SAIC in the MSFC Collaborative Engineering Center. The Workshops were conducted April 3-4 (IVHM), April 5-7 (Propulsion), April 11-12 (Airframe), April 13-14 (Launch Technologies), and April 17-18 (Operations and Range Technologies). (4/14/00)
- Facilitated review process for final report by the SPST in support of Spaceliner 100 Propulsion Technologies Prioritization effort. Delivered report to NASA. (7/7/00)
- A meeting was held with ASTP Management to discuss several follow-on tasks to the recent Spaceliner 100 Propulsion Technologies Prioritization Workshop. (8/4/00)
- Electronic form for the TIO database system was completed and sent out for use by the technology advocates. Data received was integrated and sent to evaluators. SAIC continued to work with the National Space Propulsion Synergy Team's (SPST) three task areas in follow-up to the Spaceliner 100 Workshop earlier this year. (9/1/00)

Reports/Deliverables:

Technical Report, "Bantam Technology" (WBS 2.2.1, Bantam Technology Prioritization) April 30, 1999; September 30, 2000.

2.0 Technology Assessment

2.2 Technology Prioritization

2.2.1 Bantam Technology Prioritization

2.2.1.1 Spaceliner Technology Prioritization (SPST)

Statement of Work

The contractor shall acquire the services of the Space Propulsion Synergy Team (SPST) as the core team in the completion of the Spaceliner Technology Assessment and Prioritization effort. (Mod 8)

Task Results

Summary:

Through this contract, SAIC acquired the services of the SPST to provide technical and programmatic support to NASA in formulating a "Spaceliner 100 Technology Program". The SPST offered a broad cross-section of expertise and experience. Its membership consists of senior level, volunteer representatives from across government, industry, and academia. The overall management and coordination of the support task force was assigned to Mr. Walter Dankhoff, the Executive Secretary of the SPST.

The Space Propulsion Synergy Team, in close collaboration with the NASA Spaceliner 100 Propulsion Technology Working Group, organized its technologies prioritization task force into four teams. The overall technologies prioritization process used was based directly on the Analytic Hierarchy Process (AHP) methods and techniques developed by SAIC for the Advanced Space Transportation Program beginning in the Fall of 1997. The AHP methodology is based on defining a hierarchy of prioritization criteria, collaboratively weighting the criteria, and then collaboratively making pairwise comparisons of the candidate technologies against each of the evaluation criteria. The collaborative process was further evolved along with a facilitation software tool and applied by the SPST to prioritize candidate in-space propulsion technologies for applications to five robotic space mission categories at a workshop conducted at SAIC facilities in McLean, Virginia during April 19-22, 1999. In September 1999, a series of four technology prioritization workshops was facilitated by SAIC in the MSFC Collaborative Engineering Center (CEC) for second generation RLV applications in support of the Phase III Space Transportation Architecture Studies.

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Completed facilitation of series of five back-to-back Spaceliner 100 Technologies Prioritization Workshops that were conducted across all ASTP investment areas to provide decision support to the annual NASA budget POP cycle. (5/12/00)

Reports/Deliverables:

Technical Report, "Spaceliner Technologies Prioritization" (WBS 2.2.1.1)
April 30, 2000.

Technical Report, "Report of SPST Support of Spaceliner 100 Technologies Planning"
(WBS 2.2.1.1) June 9, 2000.

Technical Report, "Spaceliner Technology Prioritization Phase II Report" (WBS 2.2.1.1)
September 30, 2000.

2.0 Technology Assessment

2.2 Technology Prioritization

2.2.2 Reusable Systems Technology Prioritization (2nd Generation R)

Statement of Work

The contractor shall coordinate with MSFC in planning and facilitating the prioritization of candidate technology investments for reusable transportation systems. The prioritization process shall encompass the inputs from technologists, engineering specialists, and program management across NASA as appropriate. Briefings and reports shall be provided as requested to facilitate reusable system programs decision-making. Briefings and reports as required by the reusable systems programs to support technology investment decision making, will be provided based on outputs from the annual technology prioritization process. (Basic)

The contractor shall coordinate with MSFC in planning and facilitating the prioritization of candidate technology investments for the Second Generation Reusable Launch Vehicle (RLV) Program of the Space Transportation Directorate. The prioritization process will use the capabilities of the MSFC Collaborative Engineering Center (CEC) to conduct a workshop or a series of workshops to develop key inputs to the technologies investment planning and decision making effort in support of the Second Generation RLV Program. The results of the process and workshop(s) shall be documented in a briefing and a final report. (Mod 15)

Task Results

Summary:

SAIC has facilitated a series of collaborative technologies prioritization assessments to support advanced space transportation technology program planning. The assessments have included facilitated workshops for in-space propulsion technologies, second generation RLV technologies, third generation (Spaceliner 100) technologies, and Human Exploration In-Space propulsion technologies. These workshops were facilitated for teams of technology evaluators ranging from all-NASA teams to combined NASA, DoD, Industry, and Academia teams.

In April 1999, SAIC facilitated a national workshop at its facilities in McLean, Virginia, to prioritize candidate in-space propulsion technologies as an input to the FY 2001 NASA budget process. During September 1999, SAIC provided facilitation of a series of NASA workshops to prioritize candidate technology and advanced development areas to support second generation RLV decision-making. SAIC also worked with NASA and the national Space Propulsion Synergy Team (SPST) to plan for the facilitation support of the Third Generation RLV or Spaceliner 100 technologies prioritization effort. On April 10 and 11, 2001, the SPST conducted a bottom-up RLV technologies prioritization workshop in the Collaborative Engineering Center (CEC) of the Marshall Space Flight Center. Although the general emphasis on the assessments was for third generation RLV systems applications, the candidate technologies derived and defined from the team's bottom-up process are likely to be applicable to second generation system architectures as well.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- A preliminary draft of observations and lessons learned from the ISP Workshop has been compiled for use in future technology prioritization workshops. Briefing to follow. (6/25/99)
- Meeting with ASTP to discuss planning, and facilitation assistance by SAIC in development of the Spaceliner 100 Technology Program. Synergy Team involvement. (7/23/99)
- As part of the STAS III effort, SAIC conducted a series of four prioritization workshops and supported the NASA meetings with the STAS III contractors in California. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Improvements in TIPS-based computer systems identified and will be implemented in preparation for Spaceliner (third generation RLV) technologies prioritization. (10/29/99)
- Maintained cognizance of continuing STAS III Second Generation RLV activity. (11/26/99)
- An Information and Modeling system to aid facilitation/management of technologies prioritization in the future is being prepared for demonstration to NASA. (1/21/00)
- Held a workshop at SAIC in which a team of NASA, industry, academia, and SAIC specialists shared potential concepts and approaches to implementation of the prototype ASTP Technology Investment Management System (ATIMS). (3/17/00)
- Discussions were held at the end of each of the Technologies Workshops to determine post-processing data needed to support development of input to the NASA budget planning effort. (4/14/00)
- Potential technologies prioritization tasks in support of the Generation 2 RLV project are being defined based on availability of the Space Propulsion Synergy Team. (6/9/00)
- Reviewed/discussed draft of potential technologies prioritization tasks in support of the Generation 2 Reusable Launch Vehicle (RLV project within MSFC/STD. (7/7/00)
- Continued work with NASA and the SPST in three task areas, two of which are being worked primarily via teleconferences. Prepared/submitted a Gen 2 RLV technologies prioritization plan. Tech. prioritization process was documented. (9/29/00)

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- Participated in meetings with the 2nd Gen RLV Program Office and with a representative of the Inter-Center Systems Analysis Team (ISAT) to discuss assessment plans. SAIC will support ISAT in reliability, safety, & cost areas. (10/27/00)
- Provided cost analysis and safety assessment support to the ISAT study of impacts of candidate technologies on a baseline two-stage to orbit, all rocket powered Second

Generation RLV Program. Continued coordination with the Space Propulsion Synergy Team (SPST) to support prioritization of related technologies. (11/24/00)

- Continued coordination of the national Space Propulsion Synergy Team (SPST) and the Integrated Technology Assessment Center (ITAC) activities related to the process and techniques for RLV technologies prioritization. (12/22/00)
- Developed three approaches to use quantitative systems analysis data to prioritize reusable systems technologies. These approaches are being assessed for their potential application to the prioritization of 2nd generation RLV technologies. (1/19/01)
- Continued to develop and assess processes and approaches that can be applied to Second Generation RLV technologies prioritization. An approach based on the use of analytic Saaty scale functions has been defined and is being investigated. (2/16/01)
- Continued to develop and assess processes and approaches that can be applied to 2nd Generation RLV technologies prioritization. The use of benefit-to-cost ratios for technologies prioritization is also being investigated. (3/16/01)
- Continued to develop and document processes and procedures that can be applied to Second Generation RLV technologies prioritization. (4/13/01)

Reports/Deliverables:

Technical Reports, "Reusable Systems Technologies Prioritization Facilitation Plans" (WBS 2.2.2, Reusable Systems Technology Prioritization)
September 30, 1999; March 31, 2000.

Technical Report, "Reusable Systems Technology Prioritization" (WBS 2.2.2, Reusable Systems Technology Prioritization, Second Generation RLV)
April 16, 2001.

Presentation, "SPST Technologies Prioritization Workshop Results", Science Applications International Corporation, April 12, 2001.

2.0 Technology Assessment

2.2 Technology Prioritization

2.2.3 Exploration Technologies Assessment

Statement of Work

The contractor shall coordinate with MSFC in planning and facilitating the preliminary assessment of candidate exploration technologies including space transportation elements for robotic and human missions. The process shall encompass the inputs from technologists, engineering specialists, cost analysts and program management across NASA as appropriate. Briefings and reports shall be provided as requested as inputs to program decision making. Briefings and reports as required will be provided to MSFC based on outputs from the technology prioritization process.

Task Results

Summary:

SAIC supported NASA in its effort to identify, assess, and prioritize candidate advanced in-space propulsion technologies, to enable potential mid-term and long-term human exploration missions. A survey of potential candidate propulsion technologies was used to identify a set of 26 technologies for preliminary screening. SAIC used a collaborative Analytic Hierarchy Process (AHP) based on a set of screening criteria, and an electronic spreadsheet for collecting AHP evaluations from participating NASA team members. The results were used as input to aid NASA in the selection of a subset of the candidate propulsion technologies for which mission and system architecture studies were performed. The studies were conducted to examine the potential performance, safety and cost payoffs that the selected technologies offer to enable future human exploration missions. Both manned and cargo missions to Mars, and to the Sun-Earth L2 libration point were considered.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Initiated review of current concepts and work being done in Mars exploration. (4/2/99)
- Prepared a preliminary report on an approach for support of exploration technology prioritization based on the national Space Propulsion Synergy (SPST) workshop. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Initiated task to assist ASTP in prioritizing candidate in-space propulsion technologies. 25 candidate technologies are being considered across two mission categories. (3/17/00)

- Completed collection/processing of data from the Inter-Center NASA team to provide initial screening of candidate propulsion technologies as input to the HEM Study. (4/14/00)
- Worked closely with NASA to identify and define the input assumptions, guidelines, and data needed to conduct the mission and systems analyses across a selected set of Mars mission architectures. (5/12/00)
Mission and system studies continue for a set of Manned Mars mission architectures based on potential high-payoff advanced in-space propulsion technologies. (6/9/00)
- The Internet Accessible version of TIPS (ITIPS) will be used in facilitating the Human Exploration Propulsion Technologies Prioritization Workshop tentatively scheduled for August 16 and 17, 2000. An electronic form for use in preparing information on candidate technologies was prepared and sent out. (8/4/00)
- The Internet Accessible version of TIPS (ITIPS) was used by SAIC in facilitating the Human Exploration Propulsion Technologies Prioritization Workshop, August 16-17, at MSFC. 37 people participated. 21 advanced propulsion technologies were prioritized for manned and cargo mission applications. (9/1/00)

Reports/Deliverables:

Technical Report, "Exploration Technologies Assessment " (Exploration Transportation Technology Assessment Plan), March 31, 1999,

Technical Report, "Exploration Technologies Assessment" (Technologies Prioritization Facilitation Plan), September 30, 1999; June 30, 2000.

2.0 Technology Assessment

2.2 Technology Prioritization

2.2.4 Future X (*Second Generation RLV*) Technologies Prioritization

Statement of Work

The contractor shall coordinate with the Space Transportation Programs Office in planning and facilitating the prioritization of candidate technology investments for the Future X Program (*Second Generation RLV Program*). The prioritization process shall encompass the inputs from technologists, engineering specialists, and program management across NASA as appropriate. Briefings and reports shall be provided as requested to support Future X decision-making. Briefings and reports as required by the Future X (*Second Generation RLV*) Program to support technology investment decision making, will be provided based on outputs from the technology prioritization process. (*Mod 7*)

Task Results

Summary:

A preliminary approach and plan were developed for conducting a process to provide the Second Generation RLV Program with decision support in planning technology investments. Prioritization of candidate technologies, based on specific criteria derived from program goals, was established. The prioritization was a collaborative effort across technical and programmatic disciplines performed by a team of qualified evaluators who were not biased advocates of particular system concepts of technologies. The prioritization process addressed both quantitative and qualitative considerations and provided an audit trail of information to support the conclusions and recommendations drawn from the prioritization data. An orientation was provided to the evaluators at the beginning of the workshop(s). The process and procedures were reviewed, and the use of the ITIPS software user interface was briefed and practiced. The evaluation team was organized into technical and programmatic subteams. The Technical Subteam prioritized candidate technologies relative to the technical criteria and subcriteria. The Programmatic Subteam prioritized technologies relative to the programmatic criteria and subcriteria. Throughout the procedure the evaluators used both quantitative data and qualitative information to do paired comparisons of technologies.

Background (Reference: WBS 2.2.4.1) Phase I of the SPST activity was directed toward a Spaceliner 100 technology assessment and prioritization effort over a period of performance from February 1, 2000, through September 30, 2000. As such, it addressed only Generation 3 Reusable Launch Vehicle applications. Phase I was carried out under WBS 2.2.1.1, Spaceliner Technology Prioritization. The Additional work for Generation 2 RLV Phase II SPST effort was implemented via WBS 2.2.4.1 and has been reported via WBS 2.2.4, as summarized below. The SPST supported the Generation 2 Program in facilitating and conducting the assessment and prioritization of the Gen2 transportation system concepts, propulsion systems and technologies. An important part of this support was the utilization of the assessment and prioritization criteria that the SPST developed and applied in previous assessment activities.

A national Space Propulsion Synergy Team (SPST) sponsored workshop was conducted on April 10 and 11, 2001, to prioritize a set of candidate technology areas to support the development of the next generations of America's reusable launch vehicle (RLV) systems. The workshop itself culminated a nine-month effort by the SPST to identify and define candidate technologies, recruit and orient a team of technology evaluators, and prepare for the use of a systematic, collaborative workshop process to facilitate the team's prioritization of the technologies. This effort was undertaken originally to support the NASA Advanced Space Transportation Program (ASTP) Third Generation RLV (Hypersonics) technology investment planning inputs to the annual NASA budget cycle. However, the effort was partially funded by the Second Generation RLV program, and the results are applicable and should be useful to the Space Launch Initiative Second Generation RLV program.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Recommended process/procedures for supporting meeting at LaRC on SL-100 roadmap. (5/28/99)
- A white paper was prepared to summarize objectives/concept for an integrated Technology Roadmap Generator Software tool, and outline potential benefits to NASA. (6/25/99)
- Provided drafts of X-37 Project Plan and Future X/Experiments Project Plan. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Provided revised draft of the Future-X/Pathfinder Flt. Experiments Project Plan. (10/29/99)
- Provided revised draft of X-37 Project Plan to MSFC. Developing other drafts. (11/26/99)

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- Several meetings/teleconferences were held with NASA and the SPST to begin planning for SPST's support of the 2nd Gen RLV Program over the next year. (10/27/00)
- Through SAIC, the SPST participated in the fall meeting of the ATWG at the NASA/ Langley. The SPST reviewed its technology prioritization process. (11/24/00)
- Prepared and gave a tutorial presentation to the SPST on the use of influence diagramming to identify key system operations and programmatic factors in achieving RLV goals. (12/22/00)
- Continued work with the national Space Propulsion Synergy Team (SPST) to support the future assessment and prioritization of candidate second-generation RLV technology investment portfolios. (1/19/01)
- Planned and facilitated technologies prioritization workshops, supported development of systems program algorithms based on the concept of influence diagramming, and assessment of analogies between aircraft and space systems developments. (2/16/01)

- Continued tasks related to planning and facilitation of a technologies prioritization workshop to be conducted on April 10 and 11, 2001. Plans are being made for the next national SPST meeting scheduled to be held at Huntsville during the week of April 9, 2001. (3/16/01)
- SAIC facilitated the national SPST Technologies Prioritization Workshop in the MSFC Collaborative Engineering Center on April 10-11, 2001. A team of seventeen evaluators prioritized twenty-six technology areas. (4/13/01)
- Documented and distributed the results of the SPST Technologies Prioritization Workshop. Requested task extension to permit scheduling of summary briefings to MSFC personnel. (5/11/01)

Reports/Deliverables:

Technical Report(s), "Future X Technologies Prioritization",
 (Technologies Prioritization Facilitation Plan), September 30, 1999.
 (Future X Program Plan), July 15, 1999.
 (Revised X-34 Project Plan), August 6, 1999.
 (X-37 Project Plan), August 27, 1999.
 (Experimental Projects Plan), September 17, 1999.

Technical Report, "Second Generation RLV Technologies Prioritization",
 September 30, 2000.

Technical Report, "Advanced RLV Technologies Prioritization by the National Space
 Propulsion Synergy Team (SPST)", April 30, 2001.

2.0 Technology Assessment

2.2 Technology Prioritization

2.2.4 Future X (*Second Generation RLV*) Technologies Prioritization

2.2.4.1 Second Gen RLV Technologies Prioritization (Gen 2, SPST II)

Statement of Work

Background (Reference: WBS 2.2.4) SAIC acquired the services of the Space Propulsion Synergy Team (SPST) as the core team in support of the Spaceliner Technology Assessment and Prioritization effort. The Space Propulsion Synergy Team (SPST) was formed under a NASA Headquarters initiative in the spring of 1991 as a voluntary participant forum of propulsion technology developers, and counterpart technology users. The associated members of the Team broadly represent government, industry, and the university community. They organize themselves, as directed by the SPST Steering Committee, into ad hoc task forces to perform specific work requested (usually) by NASA. All of this is on an informal basis, with a single exception, the overall management services of the SPST Executive Secretariat. Mr. Walter Dankhoff, a NASA retiree, provides this key facilitation function on a part-time basis. Mr. Dankhoff is a temporary SAIC employee working for a temporary agency owned by SAIC. This agency, Innovative Solutions, Inc. was formed for hiring temporary employees. Phase I of the SPST activity was directed toward a Spaceliner 100 technology assessment and prioritization effort over a period of performance from February 1, 2000, through September 30, 2000. As such, it addressed only Generation 3 Reusable Launch Vehicle applications. Phase I was carried out under WBS 2.2.1.1, Spaceliner Technology Prioritization. The Additional work for Generation 2 RLV Phase II SPST effort was implemented via WBS 2.2.4.1 and has been reported via WBS 2.2.4. The SPST supported the Generation 2 Program in facilitating and conducting the assessment and prioritization of the Gen2 transportation system concepts, propulsion systems and technologies. An important part of this support was the utilization of the assessment and prioritization criteria that the SPST developed and applied in previous assessment activities.

Task Results

(Note: Work accomplished under this WBS was reported in context with WBS 2.2.4.)

3.0 Information Technologies

3.1 Technology Database and Information System Development

3.1.1 Technologies Database Development

Statement of Work

The contractor shall develop databases that will serve to document and archive key technology data generated from NASA, industry, and academia and make it available on the appropriate storage media including computer disk and CD-ROM. These databases should support multiple types of data formats including text, video, audio, images, and integrated schedules. The databases should be secured from inappropriate access as defined by STP and should support WWW access when required. The population of these technology databases will be performed under other WP's as appropriate. The contractor shall develop and coordinate with the appropriate NASA representative a realistic development, *technology demonstration*, (*Mod 2*) and implementation plan for each database developed under this WBS. The deliverables and relative completion dates listed below represent typical database development cycles. The contractor shall develop and coordinate with the appropriate NASA representative a realistic development and implementation plan for each database developed under this WBS. The completion dates may vary depending on the complexity of the system and the user's unique requirements. Plans should be agreed upon between the contractor and the NASA representative on a specified date discussed at the database kick-off meeting.

Task Results

Summary:

SAIC developed a process for the systematic, collaborative prioritization of candidate technology investments for the NASA Advanced Space Transportation Programs Office at MSFC. The process was successfully applied to the prioritization of in-space propulsion technology investments as input to the NASA budget development process. An important element of the overall technology prioritization process was the information used by the assessment team(s) in evaluating candidate technology investments. In all of the applications of the process, the approach was to have appropriate "technology advocates" prepare white papers on each candidate technology investment according to predefined templates.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Supported the development and maintenance of the Fastrac/HTFPTA test program schedule and the Chamber/Nozzles schedule for the Fastrac engine program. (3/5/99)
- Work continues in the development & maintenance of Fastrac/HTF/PTA test program and Chamber/Nozzle schedules. STAS99 Blue Team Database work continues. (4/2/99)
- Basic approaches to the STD MIS topography and application development were laid out following collection and analysis of technical information on software solutions.

Completed NASA Headquarters data requirements for the STD FY99 Phasing Plan Update for Code R (UPN 242) MSFC inputs using the STD Resource Planning System. Completed the STD CS Manpower database and installed Applescript code on MSFC computers to automatically locate the DB on the FileMaker Pro Server and launch it. The remaining resource documents for the STAS99 Blue Team were received and incorporated into the CD-ROM and distributed to all team members on April 28, 1999. Used the SAIC multimedia laboratory to create a presentation for Danny Davis, MSFC. The clip contained the Summa Clean Room, the Stennis Control Center, and the 20-second test firing of the Fastrac engine. Plotted an E-size drawing of the firing. (4/30/99)

- Provided an updated Fastrac Engine schedule for submittal to the S&MA organization. Traveled to SSC for discussions and to provide latest MSFC Fastrac schedule inputs. Supported NASA efforts to get "Continual Improvement" presentation on the web. Demonstrated several STD and ASTP FileMaker Pro applications to members of the Rose Allen "Center Resources Team". Provided input to the RBCC planning schedule. (5/28/99)
- Provided report and data list changes to Fastrac Engine and Components Specifications Databases. Participated in Fastrac Engine scheduling activities at Stennis on 6/16/99.
- In conjunction with the MSFC Information Systems Services Office, investigated the feasibility of obtaining an Oracle kernel (the database engine) for the STD NT server. Created the STR SMART Form for data collection. The form will update the tables in the database and new information can be sent directly to the Data Handling Manager. (6/25/99)
- Continuing to revise and update schedule for chamber/nozzles for Fastrac engine program. Finalized Fastrac engine database for baselining. Updated schedule. Met with L. Thomsen, Sverdrup, and Greg Mills, PWI, to discuss and design the CDR web page. Created CDR logo in Macromedia Fireworks for Fastrac web page. Generated workforce-related reports for STD's Vehicle Systems Development Department and the Bantam Project. Completed initial implementation of the STD Task Tracking System. Completed an on-line questionnaire for STD. Demonstrated STD and SSME MIS applications to representatives of Microgravity organization. (7/23/99)
- Completed/distributed initial release of CCP internal requirements document. (7/24/99)
- Continuing to revise and update the schedule for Fastrac chamber/nozzles. (8/20/99)
- Added new section to Fastrac "Design Binder" script for the CDR RIDS page. (8/20/99)
- Developed an Excel export option for STARS in response to STD requests. Continued documenting the four core SSME MIS applications. Completed the Code R submit option of the STD POP 99 for all RLV, ASTP and STD data and reporting requirements using the STD Resource Planning System. Produced end-of-month FACS reports using NASA-provided spreadsheet data. Received updates to the STR Data Source references. Revised these for consistency and general text improvements. Vehicle/stage reports organized by vehicle family. (8/20/99)

- Completed the "Flow Process" on two CCP documents. Sent out finalized version of Fastrac Engine Specs Revision B. Completed a replan of the test matrix for the near-term engine testing being conducted at SSC. Developed a report in Microsoft Project to reflect the primary critical path of the Fastrac engine test program. Updated manufacturing schedule for 60K nozzles. Logged several "Trouble Reports" to have LCT web page accounts created for off-site users. Designed and developed the STD Work Content Dictionary. Produced a comprehensive listing of STD customized MARTS queries. Completed the Code R Submit option of the STD POP 99 for all RLV, ASTP, and STD data and reporting requirements using the STD Resource Planning System. Completed ASTP August End-of-Month (EOM) reporting requirements for dollars and civil service manpower. Completed Exploration Transportation Office EOM package. Completed daily reporting requirements for Bantam funding status via SMARTS. Effected migration of all of the WIS data to Oracle. Delivered version 1.0 of the STARS STD WIS system. Created vehicle and stage reports organized by vehicle family for the STR database. Reviewed upper stage data/parameters for compatibility with current database. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Combined Cycle Propulsion (CCP) Database data entry form completed. Sent out finalized version of Fastrac Engine Specs Revision B. Conversion into pdf file. Updated manufacturing schedule for 60K nozzles. Attended RBCC/DRACO TIM. Added a new section to the Design Binder (2.11. Vcone FlowMeter Delta P). Deploying MSFC/STD Travel System, and updated listing of STD customized MARTS queries. Completed reconfiguration of STActions DB. Modified WIS routines. Updated STR data sets on server. Reviewed upper stage parameters and data. Making list of TIPS improvements/features and ranking them per importance. (10/29/00)
- Created stand-alone MSFC copy of the Fastrac Turbopump Specification Database. Developed a test-planning schedule for testing at the Santa Susana test complex for the Fastrac engine. Continuing support of Fastrac engine manufacturing schedule. Added email features to STR Database SMART form. Researched data sources. (11/26/99)
- Successfully reinstalled NT Option Pack and PDF Filter for the index server. Modified LACE tutorial and ordered Flash documentation. Completed preliminary design review of the Santa Susana Field Laboratory. Added numerous activities to the Fastrac schedule. Updated the test matrix portion. Working with X-33 Hydrogen Tank Incident Team to develop/update schedule. Identified/contacted 36 companies to encourage feedback on STR database. Checked on iThink/other software for creating "Road Map" charts/simulations. (12/24/99)
- Provided CCP technical paper to multimedia Developer for use with current LACE example. Identified specific list of CCP documents to be included in the demonstration database. Finished configuring new multimedia machine to be used for generating presentations for the CCPD. Generated reports to display data flow/relationships. Searched Fastrac Engine database for comments and created report to address database baseline modification. Organized new launch information

- for inclusion in STR database. Converted some PowerPoint charts to GIF files for the AIMS web page. Added shape and color-coded bullets to enhance visual appeal and aid in navigation. (1/21/00)
- Created a procedural plan for each Fastrac database after it has been baselined. Completed CDR section of the LCT web page. Added links to the RIDS system. Discussed STR data for Delta vehicles with STK developers. Discussed possible enhancements to the STR Database. Explained TIPS process to NASA personnel. Discussed Systems Model with D. Anderson and E. Hyde, MSFC. Dick Foster, SAIC Consultant involved in discussions. Approach demonstrated to G. Lyles on 2/4. (2/18/00))
 - Created new Fastrac Engine specifications database for the next baseline requirements set and modified screen layouts for requirements reporting. Wrote instructions for accessing TIPS stdftp web site for white papers for upcoming workshops. (3/17/00)
 - Approximately fifty-five new vehicles have been added. Suggestion was made by SAIC to make another CD to distribute to select people and to aid in a demonstration. Set up databases for RLV Propulsion, IVHM, Airframe, and Launch Technologies and administrated these databases for the Technologies Evaluation Workshop. (4/14/00)
 - Set up database for Second Generation Range and Operations Technologies evaluation workshop. Administered the system at the workshop. Created reports for review. Resolved a slowness problem with the TIPS user interface by installing 64M more memory, bringing the total to 128M. Also eliminated background tests and compacted the database. Created a full set of priority charts for the five workshops and provided input to the SPST workshop report. (5/12/00)
 - Received FileMaker Pro 5 Developer for use with the Fastrac Engine Database. Setting up Internet version of TIPS on a new Compaq laptop to use in the upcoming Human Exploration Technology (HET) technology prioritization. (6/9/00)
 - Set up Internet version of TIPS on laptop for use in upcoming HET technology prioritization. Adding features from the TIO database to the TIPS database. Met with Chuck Smith on 26 June to discuss SAIC approach for performing DBMS research. Delivered Mid-Term report to Chuck Smith on 29 June. (7/7/00)
 - Created a template form for the white papers. Collated the technologies, advocates, quad chart files and Excel files, and created emails to each advocate. Delivered CCPD presentation at the Joint Propulsion Conference. Contacted D. Bellezza, President of Kaiser Marquardt regarding acquisition of documents identified in March. Comprehensively reviewed all "in house" documents. Sent out introductory CCPD information and requested password and identification preferences for the Beta test group. Inputted new users/passwords into CCPD. (8/4/00)
 - Made modifications to MC-1 Verification Database housed at MSFC. (9/1/00)

Reports/Deliverables:

Technical Reports/Software/Demonstrations, "Technologies Database Development"
 (STP Contracts Database Operational S/W & Documentation), September 30, 1999.
 (STAS99 Database Software), February 28, 1999.

(Develop STD Civil Service Workforce Tracking System), September 30, 1999.
(Develop STD Financial Tracking System), September 30, 1999.
(Develop STD Action Item Tracking System), September 30, 1999.
(Document Automated Systems), September 30, 1999.
(CD-ROM & Video Tape of Future X Pathfinder), July 31, 1999.
(Past, Present & Future CD-ROM Replication Delivery), August 1, 1999.
(Preliminary Report on Status of Future Technology CD-ROM), November 30, 1999.

Technical Report, "Technologies Database Development" (TIO Database Operational Software and Documentation), June 30, 2000.

3.0 Information Technologies

3.1 Technology Database and Information System Development

3.1.1 Technologies Database Development

3.1.1.1 NASA X-37 Public Relations CD-ROM (Media Fusion)

Statement of Work

SAIC shall develop databases that will serve to document and archive key technology data generated from NASA, Industry, and Academia and make it available on the appropriate storage media, including computer disk and CD-ROM. SAIC will provide a CD-ROM animation of the X-37 to demonstrate its technology, operation, and functions. The CD-ROM will be used as an information product to be distributed to a broad audience. (Mod 7)

The contractor shall conduct interviews with key personnel at the Boeing Company in Seal Beach, CA, NASA personnel at Dryden Research Center at EAFB, CA, key personnel at NASA Headquarters, in Washington DC, and key personnel at the Pentagon. The contractor shall coordinate the interviews, travel to the location, tape the interview and edit the final footage into the CD-ROM. The contractor shall create a virtual tour of MSFC describing the Center's capabilities in a brief summary and integrate it into the presentation. (Mod 15)

Task Results

Summary:

The CD-ROM product associated with this task was developed and subsequently demonstrated to NASA/MSFC Pathfinder Program Office personnel by Media Fusion representatives. The CD-ROM master and its demonstration at MSFC constituted the deliverable associated with this task.

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- Video interviews held with X-37 personnel at Dryden. The CD-ROM is being concluded and a near-final review disc is expected soon. (2/16/01)
- The subcontracted task for development of the X-37 CD-ROM has been completed. The task deliverables have been submitted to MSFC. (6/8/01)

Reports/Deliverables:

"X-37 Public Relations CD-ROM"

3.0 Information Technologies

3.1 Technology Database and Information System Development

3.1.1 Technologies Database Development

3.1.1.2 Space Transportation CD-ROM, Phase II (EMI)

Statement of Work

SAIC shall develop databases that will serve to document and archive key technology data generated from NASA, Industry, and Academia and make it available on the appropriate storage media, including computer disk and CD-ROM. (Mod 7)

SAIC will partner with Engineered Multimedia, Incorporated (EMI) to support NASA in the development of a Space Transportation CD-ROM. Building on experience gained in its previous development of a CD-ROM for NASA/MSFC, EMI will accomplish a Phase II production of CD-ROMs designed to showcase emerging NASA technologies. This activity shall focus on propulsion systems, integrated vehicle health management, and flight technologies. Prior to production, EMI will produce a comprehensive design document or script. Upon completion of the design EMI will provide a range of production strategies to meet the delivery dates, and expanding production value requirements of NASA/MSFC. (Mod 15)

Task Results

Summary:

SAIC/EMI accommodated NASA/MSFC's comments and recommendations resulting from reviews of the earlier draft CD-ROM product. The CD-ROM product associated with this task was completed on schedule and delivery was effected via a demonstration briefing to NASA/MSFC representatives on January 18, 2001, at SAIC. An advance copy of the CD-ROM was provided to MSFC prior to the meeting. In concluding follow up to comments made at the meeting, minor editorial changes to the CD-ROM were made by EMI.

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00)

- A demonstration of the final Space Transportation "New Horizons" CD-ROM was given by SAIC subcontractor, Engineered Multimedia, Inc., to NASA/MSFC and SAIC representatives on January 18, 2001, at the SAIC facility. (1/19/01)
- Two CD-ROM products, "Microgravity" and "New Horizons", were delivered to MSFC technical representatives at a briefing at SAIC on January 18, 2001. (2/16/01)

Reports/Deliverables:

CD-ROM, "Space Transportation, New Horizons", January 2001.

3.0 Information Technologies

3.1 Technology Database and Information System Development

3.1.1 Technologies Database Development

3.1.1.2 Space Transportation CD-ROM, Microgravity (EMI)

Statement of Work

SAIC shall develop databases that will serve to document and archive key technology data generated from NASA, Industry, and Academia and make it available on the appropriate storage media, including computer disk and CD-ROM. (Mod 7)

SAIC shall partner with Engineered Multimedia, Incorporated (EMI) to apply appropriate technical expertise and multimedia production capability to develop a vivid multimedia CD-ROM that documents emerging Microgravity technologies. In its development of a Microgravity CD-ROM, SAIC/EMI shall use and enlarge upon its previously developed capabilities to entertain and educate viewers to the science of microgravity research. (Mod 15)

Task Results

Summary:

SAIC/EMI accommodated NSAS/MSFC's comments and recommendations resulting from reviews of the earlier draft CD-ROM product. The CD-ROM product associated with this task was completed on schedule and delivery was effected via a demonstration briefing to NASA/MSFC representatives on January 18, 2001, at SAIC. An advance copy of the CD-ROM was provided to MSFC prior to the meeting. In concluding follow up to comments made at the meeting, minor editorial changes to the CD-ROM were made by EMI.

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- A demonstration of the final "Microgravity" CD-ROM was given by SAIC subcontractor, Engineered Multimedia, Inc., to NASA/MSFC and SAIC representatives on January 18, 2001, at the SAIC facility. (1/19/01)
- CD-ROMs were produced by Engineered Multimedia, Inc. (EMI) under subcontract to SAIC. Two CD-ROM products, "Microgravity" and "New Horizons", were delivered to MSFC technical representatives at a briefing at SAIC on January 18, 2001. (2/16/01)

Reports/Deliverables:

CD-ROM, "Space Transportation, Microgravity", January 2001

3.0 Information Technologies

3.1 Technology Database and Information System Development

3.1.1 Technologies Database Development

3.1.1.3 ISE Support for Reusable Space Transportation System

Statement of Work

In support of the Reusable Space Transportation System (RSTS) team, SAIC shall perform the following tasks to provide Intelligent Synthesis Environment (ISE) related assistance:

Task 1 – Requirements Development and Tracking

Task 2 – Coordination and Facilitation

Task 3 – Technical Support

(Mod 10)

Task Results

Summary:

The Mid-Term Report summarized the activities to be performed by SAIC under Modification 10 to this contract. As stated in this report, the emphasis of the services to be provided by SAIC will be on the recommendation of a Database Management System (DBMS) for use by the RSTS Application ISE CEE Team. The DBMS recommended will be intended to fulfill the requirements for a "Dynamic Database" as described in section 8.4 of the *ISE RSTS Application Requirements Document Version 1.0*.

As reported in the Final Report, SAIC's Project Approach consisted of the following four tasks:

- A. Review Requirements
- B. Interview Key ISE RSTS Application Personnel
- C. Interview Industry Experts
- D. Research COTS Solutions

In this report SAIC presented a summary of the process SAIC followed to arrive at a recommendation after completion of the four Project Approach Tasks. After arriving at an understanding of the RSTS application database needs and conducting a comparison of potential products that could meet those needs, SAIC recommended three possible OODBMS solutions in order of rank: VERSANT, Objectivity/DB, and Cache.

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Researching OODBMS via Internet and IT journals. Sent request to Exxon Mobile Corp. to discuss Objectivity DB. Constructed draft matrix for comparisons. (9/1/00)
- Completed checklists with multiple possibilities for DBMS. Researched ODBMS technical terms and issues. Purchased ODBMS Needs Assessment Manual. (9/29/00)

Reports/Deliverables:

Technical Report, "ISE Support for RSTS" (Mid-Term Report), June 30, 2000.

Technical Report, "ISE Support for RSTS" (Final Report), September 30, 2000.

3.0 Information Technologies

3.1 Technology Database and Information System Development

3.1.1 Technologies Database Development

3.1.1.4 Second Generation RLV Program Database

Statement of Work

The contractor shall identify, develop, and apply database tools and techniques to enhance the assimilation and distribution of space transportation technologies using state of the art computer aided design and web based concurrent commercial off the shelf software (cots) Working with NASA activities and organizations, the contractor shall identify and recommend the best available tools to incorporate the most design efficient and robust database technology into 2nd Generation RLV focused programs. The contractor shall be physically located on-site at MSFC. (Mod 15) Mr. Robert Robb, SAIC, has been given special status by NASA/MSFC to support Source Evaluation Committee activities associated with NRA 8-30 proposals. (Mod 18)

Task Results

Summary:

Delivered databases to six NASA centers (MSFC, KSC, JSC, LaRC, & ARC). Trained users.

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Supported TD20 Inter-Center Working Group (IWG). Supported development of the NAS8-30 Requirements Document. Developing WBS Dictionary database. (9/1/00)
- Met with Dr. Richard Evans, George Mason University, and discussed a NASA System Design Curriculum... the "Ten Tenets of NASA System Design. (9/29/00)

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- Received technology database inputs from individual NRA-27 contractors. Merged inputs into a consolidated database. Developed model DPD for NRA. (10/27/00)
- Continuing to develop a Source Evaluation Database to track the findings from the NRA8-30 Source Evaluation Committee (SEC). (11/24/00)
- Support was provided to the NRA 8-30 Source Selection Board. (12/22/01)
- Provided Information Technology (IT) support during the evaluation phase for NRA8-30, 2nd Generation RLV Systems Engineering and Risk Reduction NASA Research Announcement. (6/8/01)
- SAIC is developing a Risk Management Database that will be utilized by the Program Office and all Projects to identify, plan and track risks. (7/6/01)
- Continued development support of the 2nd Gen Risk Management Database. (8/31/01)

Reports/Deliverables: Source Evaluation DB (12/5/00), Risk Management DB (8/15/01)

3.0 Information Technologies

3.1 Technology Database and Information System Development

3.1.1 Technologies Database Development

3.1.7 Space Transportation CD-ROM, Phase II (EMI)

Statement of Work

SAIC shall develop databases that will serve to document and archive key technology data generated from NASA, Industry, and Academia and make it available on the appropriate storage media, including computer disk and CD-ROM. (Mod 7)

SAIC will partner with Engineered Multimedia, Incorporated (EMI) to support NASA in the development of a Space Transportation CD-ROM. Building on experience gained in its previous development of a CD-ROM for NASA/MSFC, EMI will accomplish a Phase II production of CD-ROMs designed to showcase emerging NASA technologies. This activity shall focus on propulsion systems, integrated vehicle health management, and flight technologies. Prior to production, EMI will produce a comprehensive design document or script. Upon completion of the design EMI will provide a range of production strategies to meet the delivery dates, and expanding production value requirements of NASA/MSFC. (Mod 15)

Task Results

(Note: Work accomplished under this WBS was reported in context with WBS 3.1.1.2)

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.1 Identify Tools and Techniques

Statement of Work

The contractor will identify, develop, and apply engineering tools and techniques to enhance the analysis of space transportation technologies using state of the art computer aided analysis, web based concurrent engineering methods, and next generation design and cost tools. Working with NASA activities and organizations, the contractor will identify and recommend the best available tools to increase design confidence, reduce cost, cut the design cycle times, and rapidly insert new technologies into RLV focused programs. Deliverables will be documented recommendations of identified tools and techniques applicable to RLV and related programs. (Mod 2, 12)

Task Results

Summary:

In 1999, SAIC developed a software tool (STiKMan 1.0) to assist MSFC in managing and converting CAD-derived facet model content for Satellite Tool Kit Visualization Option (STK/VO) visualizations. The tool runs on Silicon Graphics computers, and allows a user to assemble, manipulate, and decimate model parts derived from disparate CAD sources. A unique feature is the capability to create STK/VO part articulations (e.g., a robot arm motion) in the STK/VO articulation and articulation timing languages, allowing the construction of highly complex visualizations and videos.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Prototype conversion methods were devised for both model geometry and articulations for the "Tools and Techniques" task initiated this period in support of MSFC. (8/20/99)
- A simple demonstration case for "Tools and Techniques Development" was generated with AutoCAD and transported to the model management program being modified from the SAIC program, Model Man. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Remaining software requirements completed on CAD-STK conversion effort. (10/29/99)
- Accomplished all requirements/actions and the Modeling Report of Task 4.1.1, Tools and Techniques Development. Provided related training to NASA and contractors. (11/26/99)

- Prepared/presented an approach to developing an ASTP Information and Modeling System (AIMS) tool. Software system will be Internet-accessible, w/password. (1/21/00)
- Progressed in the development of the "ATIMS" systems model software tool needed by the ASTP office for assessing and prioritizing Generation 3 RLV technologies. (4/14/00)
- Development of the "ATIMS" model software tool progressed to the initial proof-of-concept stage. It was demonstrated to ASTP managers on 10 May at SAIC. (5/12/00)
- Completed/delivered reports, "Determination & Verification of Tools", "Introduction of Tools into Programs", and "Recommendation for Advanced Tools/Models". (9/1/00)
- Completed/delivered reports on "Systems Technology Blueprint", Integrated Systems Model", "Integrated Systems Model with Windows Based Software" and "Expanded Definition of the Robust Design Simulation Architecture. (9/29/00)

Reports/Deliverables:

Technical Report, "STiKMan 1.0 User's Guide," Paul Griffiths, November 1999.

Technical Memo, "Converting a CAD Model to STK/VO Format," Elizabeth Delugach and Jay Farrell, November 1999.

Technical Memo, "Using STiKMan to Add Articulations to an STK/VO Model," Elizabeth Delugach and Jay Farrell, November, 1999.

Software Disk, "STiKMan 1.0," November 1999.

Training Class on STiKMan, along with training notes, November 23, 1999.

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.2 Technology Evaluation and Analysis

Statement of Work

The contractor will provide qualified, expert personnel with extensive experience in the appropriate disciplines to perform engineering evaluations, validation and verification, and analyses of concepts, systems related technologies, and programs. In addition, the contractor shall develop a comprehensive set of options for improving the safety and reliability of the Space Shuttle and providing multiple pathways to airline-like levels. (Mod 1) SAIC shall provide system design and engineering support to the FutureX/Pathfinder activity. The contractor shall provide project management, technical expertise and any other services required to accomplish the development of a web based CCPD including the delivery of a working version to NASA for server implementation. In addition, the contractor will provide program plan templates, briefings and reports as requested and will develop a comprehensive set of options for improving the safety and reliability of launch systems and providing multiple pathways to airline-like levels. Analyses will include a probabilistic risk assessment of potential options. (Mod 7) These capabilities and qualifications will enable the contractor to develop and employ advanced analysis and design synthesis computational tools and information processing means for accurately and promptly conducting required advanced space transportation systems analysis and carrying out detailed conceptual-level design processes. In the key technology area of advanced combined airbreathing/rocket propulsion, the contractor will contribute to the development of knowledge-based repositories and active databases, assist in identifying supporting technology program strengths and areas needing reinforcement, and support the development of in-house systems analysis/synthesis capabilities. The contractor will also assist in conducting subject-relevant engineering liaison with other government agencies, industry and the university communities, while maintaining an informed awareness of international developments in the field of advanced space transportation and propulsion systems. (Mod 15) A final report showing all data, models, and assessments will be written after consultation with appropriate NASA personnel. The elements of this document are Subsystems & Requirements, Internal and External Diagrams, Specifications & Requirements Mapping, Historical Comparisons & Testing, and Knowledge Consultation.

Task Results

Summary:

This specific technical subject is generally cited as combined airbreathing/rocket propulsion, with a concentration on the subset area, combined-cycle propulsion (CCP). The effort was carried out as the principal activity of Mr. William J. D. Escher of SAIC's Huntsville Operations. The effort was generally accomplished in addition to that carried out in direct support of the NASA ASTP Combined-Cycle Propulsion Database (CCPD), WBS Item 4.1.2.6. Efforts carried out by Mr. Escher under WBS 4.1.2 during the period October 1, 1999 through September 30, 2001 are supported by documents annexed to the WBS 4.1.2

September 30, 2000 milestone report and the WBS 4.1.2 September 30, 2001 final report. These are listed and overviewed under the subsequent "Reports/Deliverables" heading.

WBS 4.1.2 also included early work performed in context with the "Reusable Flyback System (RFS), the X-37, and the "Space Shuttle Orbiter Risk Study". Limited reference to this early work under WBS 4.1.2 is included in the following list of "Key Items". Subsequent work on the X-37 was covered, and is reported herein, under WBS 4.1.2.2, "Future X/Pathfinder Technologies, X-37". Subsequent work on Space Shuttle Orbiter risk was covered and reported separately under GSA contract, T-6398W. This study, "Assessment of Space Shuttle Abort Risk", was performed for the Johnson Space Center (JSC).

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Supported development of Space Transportation Resources (STR) database. Participated at KSC as the STAS99 database and report were finalized and reported to senior NASA officials. (3/5/99)
- A complete reference library was obtained and reviewed in support of the STAS99 Blue Team. Completed analysis of Shuttle upgrades, reliability estimates, and costs. (4/2/99)
- A text-facing-graphics overview presentation brochure was prepared for the ASTP Office and distributed to several organizations at MSFC and elsewhere within NASA. (4/30/99)
- Mr. W. Escher visited GRC on April 12, 1999. Coordination meetings with GRC's Hypersonic Propulsion Office were held and an update on *Trailblazer* was given. (5/28/99)
- Continued design and development of RBCC database. Engineering content of the database will closely resemble a Knowledge Base. (7/23/99)
- Initially processed some 20 documents into the CCP database. Completed special review, "Current Trends in Rocket Based Combined Cycle Technologies". (8/20/99)
- Active in telecons with a special task team of the Space Propulsion Synergy Team, which is attempting to support MSFC's Spaceliner 100 forward planning effort. (8/20/99)
- With Pratt and Whitney plans to relocate jet engine engineering work to Connecticut, P&W Florida will be used for sea level jet engine tests. Component stands for jet engine components are being closed. Altitude tests will be made at CT or AEDC. (9/30/99)
- The X-37 vehicle design is maturing. The size has increased slightly to provide better aerodynamics. The hydrogen peroxide tank is no longer integral with the skin, but is structurally separate because of heating concerns. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Scanned in selected documents for incorporation into the CCP Database. Supported development of functional requirements for Spaceliner 100 class of systems. (10/29/00)

- Participated in International Symposium on Airbreathing Engines (ISABE) and multi-center presentations on demonstration of rocket/airbreathing CCP operations. (10/29/00)
- Priority documents were processed into the Combined-Cycle Propulsion Database (CCPD). Prepared a one-year work plan for comprehensively populating the database. Participated in the Ninth AIAA International Space Planes and Hypersonic Systems and Technologies Conference. Presented vugraph briefing of 12-thrust chamber air-augmented rocket ground test system. Participated in the Airbreathing Launch Vehicle (ABLV) inter-center coordination meeting at MSFC, including related TIMS. (11/26/99)
- Gathered/prioritized key documents received from ASTP for CCPD inclusion. (12/24/99)
- Continued support of Team 2, "System Architectures", via action items/telecons. (12/24/99)
- Attended and gave briefing at Georgia Tech Aerospace Engineering School's Space Systems Design Laboratory (SSDL) second annual program review on 12/1/99. (12/24/99)
- Resumed Orbiter Abort Study to provide a quantitative estimate of intact abort loss-of-vehicle (LOV) potential. Produced mid-term report of current status and plans. (12/24/99)
- CCPD work involves screening of the significant document resources being made available from the former MSFC/Propulsion Laboratory's repository, via Eric Hyde. Perspective and Synopsis sections have been prepared for 15-18 database entries. (1/21/00)
- Summary reports were made covering the 9th AIAA International Space Planes and Hypersonic Systems & Technologies Conference held in Norfolk, VA, 1-5 Nov. (1/21/00)
- Developed an Orbital Maneuvering System dynamic risk model. Integrated it into the Dynamic Abort Risk Evaluator. Prepared presentation for working group. (1/21/00)
- Screening continues of the significant document resources available from the former MSFC Propulsion Laboratory's CCP archival repository. Tutorial script for Ejector Ramjet was prepared for subsequent graphic processing for the Database. SAIC continues to work with the ASTP Office and STD procurement to effect participation by the Space Propulsion Synergy Team (SPST) in CCP activities. Cost model background information for Gen 3 evaluation was provided in follow-up to SAIC participation in RBCC contractor's telecon chaired by MSFC on 2/7/00. Participated in Orbiter Abort Risk meetings at JSC to review technical data and current status of modeling effort. Collected information relevant to RTLS/TAL models. (2/18/00)
- Presented an impromptu "white paper" on turbine-based combined cycle propulsion at the Spaceliner 100 Technology Prioritization Workshop at MSFC on 5-7 April. A report on the SPST Workshop is in preparation and will be released in time to assist NASA's budgetary planning activity that will wrap up at the end of April. Participated in several telecons conducted by the SPST Steering Committee. Walt Dankhoff, SPST Executive Secretary, noted a number of follow-on action items. SAIC personnel visited Kaiser-Marquardt facilities to canvas documentary holdings for potential assimilation into the NASA CCPD. Identified, cataloged, and boxed

some 275 applicable documents. An enabling SAIC/KM draft agreement is being pursued. (4/14/00)

- An SAIC team, supported by Kaiser Marquardt's staff in Van Nuys, successfully identified, catalogued, and boxed some 275 documents applicable to CCPD. (5/12/00)
- Prepared two SPST "Phase II" work packages to cover several new tasks to be performed during the period from June 15 through September 30, 2000. Continuing to support the MSFC Engineering Cost office toward development of the life-cycle cost estimation means for airbreathing propulsion systems. (6/9/00)
- Distributed SPST final report via email and bound paper copies. An AIAA Joint Propulsion Conference (JPC) paper based on this report was prepared. It will be presented on 19 July by Mr. Walter Dankhoff, SPST Executive Secretary. Other papers, lead-authored by SAIC, will be presented on the Combined-Cycle Propulsion Database (CCPD) and the Supercharged Ejector Ramjet (SERJ), Marquardt's Jet Laboratory, presently in a "mothballed readiness" state, now stands to be decommissioned, scrapped-out and ultimately demolished. It has been pointed out that this facility could possibly support NASA's RBCC engine development efforts toward test qualification of planned flight demonstration propulsion systems. (7/7/00)
- Work continues on the "Aviation Analog for Spaceflight" as applied to Gen 2 and Gen 3 RLV areas. A joint MSFC/SAIC progress report on the CCPD was presented at the Joint Propulsion Conference (JPC) on 7/19/00. A technical paper on the 1960's Supercharged Ejector Ramjet (SERJ) engine exploratory development activity was also presented at the JPC. Mr. T.A. Heppenheimer, the well known aerospace technical writer, visited SAIC on 7/10/00 to exchange information that will aid in his NASA/Langley-commissioned preparation of a NASA Hypersonics History Document. Assistance to the MSFC Engineering Cost Office continues in the development of life-cycle cost estimation means for Gen 3 airbreathing propulsion systems. (8/4/00)
- Provided direct support of the executive secretary function for SPST efforts focused on Generation 2 and 3 Reusable Launch Vehicle subjects. Work continues on the "Aviation Analog for Spaceflight" for both the Gen 2 and Gen 3 applications. Supported development cost estimates for the prototype rocket engine planning for Gen 2 RLV's. Will include Gen 3 airbreathing propulsion systems as well. (9/1/00)
- Obtained and provided to NASA the program for the JANNAF meetings to be held 13 November in Monterey, California. Provided a partial bibliographic listing of aviation books. Visited WPAFB to obtain high-speed propulsion information. (9/29/00)

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- The Space Propulsion Synergy Team's efforts, focusing on Gen 2 and 3 RLV subjects, continues with SAIC providing direct support of the executive secretary function. W. Escher presented a paper, "CCP Ejector Mode Using a Monopropellant Hydrogen Peroxide Primary Rocket Subsystem" at Penn State University. Five boxes

- of several hundred selected documents, borrowed from the Air Force Aero Propulsion Documentation Repository at WPASB were returned by SAIC. These documents were electronically scanned at SAIC for entry into NASA CCPD. (10/27/00)
- SAIC provided specialist representation at three events during this reporting period: (1) NASA Institute for Advanced Concepts (NIAC) Workshop at Atlanta, GA, on November 7-8; (2) Third International Hydrogen Peroxide Propulsion Conference, held at Gulfport, MS, on November 13-15; and (3) Annual JANNAF Propulsion Meeting at Monterey, CA, during the week of November 13-17. Summary reports on each of these events, written by the SAIC participants, are available. SAIC is providing support to the Space Propulsion Synergy Team (SPST) Executive Secretary function in continuing efforts to focus on Generation 2 and 3 RLV subjects via steering committee and full-membership biweekly calls. (11/24/00)
 - A ground-launched, subscale hydrogen-fueled flight development and demonstration system, nominally titled DC-XB, was described in several limited-distribution draft position papers. Meetings were held on the status and future efforts on the CCPD activity. An expanded effort will be proposed for the continued acquisition and processing of vital documents leading to the long-term development/maintenance of the CCPD. (12/22/00)
 - Follow up discussions with Mr. Craig Hansen, AFRL-EAFB, continue. A specific mission/vehicle concept has been posed to SAIC and Lockheed Martin's Huntsville offices. This involves a SMV orbital launch in a "pop up" operation. The Aviation Analog for Spaceflight SPST Task Team effort, presently being focused on propulsion systems and technologies being compared between aircraft gas turbine and liquid-propellant rocket engines, will be reviewed in a general working session scheduled at SAIC-Huntsville on February 6-7, 2001. (1/19/01)
 - Presentation brochure, "Aviation/Space Analog Team Interim Report" was provided to Space Propulsion Synergy Team (SPST) members and to NASA personnel. Wrap-up of effort will be a mid-April briefing to both MSFC and the full SPST membership. Support to Phase 2 of CCPD ends 3/31/01. Phase 3 continuation effort planned with emphasis on technical info content. (2/16/01)
 - A CCPD Phase II report and demonstration event are scheduled for the end of March. A user participation activity is planned in which several MSFC engineers working in the combined-cycle propulsion field will jointly work with the CCPD from individual computer terminals. Work continues on the existing video workprint, "Back to the Future," toward a possible revised and expanded version highlighting more recent progress under the ASTP ART and ISTAR initiatives. (3/16/01)
 - Copies of the SPST's revised "Aviation/Space Analog Team Report" were prepared. The initial-phase report was presented to MSFC representatives and the full SPST Team by Pete Mitchell on April 12, 2001. The original digital tapes of the CCPD video, "Back to the Future" have been forwarded to MSFC for processing as a starting point for changes/expansion. (4/13/01)
 - Summarized the SPST Generation 3 RLV Prioritization Workshop findings in a report issued on April 25, 2001. Provided copies of the SPST report, "Aviation Analog for Spaceflight", to a large number of individuals and organizations expressing interest in this effort. Participated in the three day "Global Air and Space

2000 Conference" presented by the AIAA and sponsored by Pratt & Whitney. (5/11/01)

- The Space Propulsion Synergy Team's Aviation Analog for Spaceflight Task Team has completed final documentation of its findings. The report has been widely distributed and the findings will be presented to the MSFC Center Director in the near future. (6/8/01)
- A set of color-coded simplified schematic drawings of the Supercharged Ejector Scramjet engine has been completed for use in a forthcoming animated CCPD "tutorial" feature. SAIC personnel are supporting several conferences over the next couple of months that are expected to have CCPD relevance. SAIC personnel supported a NASA Hypersonics Workshop held 19-20 June at the National Space Science and Technology Center (NSSTC). SAIC representatives gave orientation presentations and facilitated breakout group activities. (7/6/01)

Reports/Deliverables:

Technical Report: "RFS Jet Engine Assessment Report", June 30, 1999.

Technical Report: "Technical Evaluation and Analysis of Combined-Cycle Propulsion Systems and Technologies", (WBS 4.1.2, Technology Evaluation & Analysis), September 30, 2000. This report included the following annexes:

Summary Review: "AIAA 9th Hypersonics and Spaceplanes Conference", November 1-5, 1999, at Norfolk, Virginia.

A pivotal technical theme arising from this international meeting, which focused on high-speed flight systems and technologies, was the universal interest expressed in combined propulsion for powering the many advanced aerospace transportation system concepts, as described by representatives of those leading nation participants.

White Paper: "Spaceliner 100 Candidate Technology: Combined-Cycle Propulsion", prepared for the NASA/SPST Spaceliner 100 Technology Prioritization Workshop, April 5-7, 2000, at NASA/MSFC.

This paper, distributed well in advance of the workshop for tutorial benefit of the expert reviewers involved, was written to a guideline reference "template" used to ensure a consistent degree of uniformity among the numerous subjects to be addressed.

Meeting Report: "Airbreathing Launch Vehicle (ABLV) Studies Status Report", September 1999, at NASA/MSFC.

NASA/LaRC presented findings that RBCC-powered, horizontal takeoff and landing single-state-to-orbit vehicles were found to be sized at well over horizontal operation permitted takeoff gross weights. The significant disparities in vehicle weights and aerodynamic parameters among the several study groups reporting on their results

reference “template” used to ensure a consistent degree of uniformity among the numerous subjects to be addressed.

Meeting Report: “Airbreathing Launch Vehicle (ABLV) Studies Status Report”, September 1999, at NASA/MSFC.

NASA/LaRC presented findings that RBCC-powered, horizontal takeoff and landing single-state-to-orbit vehicles were found to be sized at well over horizontal operation permitted takeoff gross weights. The significant disparities in vehicle weights and aerodynamic parameters among the several study groups reporting on their results were notable, and a number of corrective action assignments followed as this meeting was terminated without fully completing its agenda.

Draft Prospectus: “An Aviation Historical Analog for the Planning of an Astronautics Future”, by SAIC, 1999.

As a result of this draft, a task team was established by the Space Propulsion Synergy Team (SPST) to critically address the “aviation experience” for guidance in NASA’s pursuit of “aircraft-like” reusable space transportation systems and technology.

Technical Paper AIAA-2000-3109: “Marquardt’s Mach 4.5 Supercharged Ejector Ramjet High-Performance Aircraft Engine Report”, presented by SAIC at the 36th Joint Propulsion Conference, July 16-19, 2000, at Huntsville, Alabama.

The fact that this specific Combined Cycle Propulsion (CCP) system had originally been directed to advanced reusable launch vehicle applications, where it was shown to be quite competitive but had subsequently been successfully applied to high-performance aircraft, is deemed significant to future Spaceliner-class programs.

Technical Report: “Final Report, Technical Evaluation and Analysis” (WBS 4.1.2, Technology Evaluation & Analysis), September 30, 2001. This report included the following annexes:

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.2 Technology Evaluation and Analysis

4.1.2.1 Future X/Pathfinder Program Plans

Statement of Work

The contractor will provide qualified, expert personnel with extensive experience in the appropriate disciplines to perform engineering evaluations, validation and verification, and analyses of concepts, systems related technologies, and programs. A final report showing all data, models, and assessments will be written after consultation with appropriate NASA personnel. The elements of this document are Subsystems & Requirements, Internal and External Diagrams, Specifications & Requirements Mapping, Historical Comparisons & Testing, and Knowledge Consultation. (Mod 7)

Task Results

Summary:

The program plans developed in support of the FutureX/Pathfinder activity were carried out and reported in context with WBS 2.2.4, "Future X Technologies Prioritization". The reports produced are also listed under the "Reports/Deliverables" heading within this WBS 4.1.2.1 item. Similarly, the key items associated with this effort were delineated in the overview of WBS 2.2.4. These are singled out and repeated under the headings that immediately follow.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Provided drafts of X-37 Project Plan and Future X/Experiments Project Plan. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Provided revised draft of the Future-X/Pathfinder Flt. Experiments Project Plan. (10/29/99)
- Provided revised draft of X-37 Project Plan to MSFC. Developing other drafts. (11/26/99)

Reports/Deliverables:

Technical Report(s), "Future X Technologies Prioritization",
(*Technologies Prioritization Facilitation Plan*), September 30, 1999.
(*Future X Program Plan*), July 15, 1999.
(*Revised X-34 Project Plan*), August 6, 1999.
(*X-37 Project Plan*), August 27, 1999.
(*Experimental Projects Plan*), September 17, 1999.

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.2 Technology Evaluation and Analysis

4.1.2.2 FutureX/Pathfinder Technologies Specialist, X-37 (*Jim French*)

Statement of Work

The contractor will provide qualified, expert personnel with extensive experience in the appropriate disciplines to perform engineering evaluations, validation and verification, and analyses of concepts, systems related technologies, and programs. A final report showing all data, models, and assessments will be written after consultation with appropriate NASA personnel. The elements of this document are Subsystems & Requirements, Internal and External Diagrams, Specifications & Requirements Mapping, Historical Comparisons & Testing, and Knowledge Consultation. (Mod 7) Mr. Jim French, of JRF Engineering Services, a consultant to SAIC, will provide system design and engineering support to the Future X/Pathfinder activity. He shall continue to assist with issues of overall system design, test, and operation on X-37, as well as 2nd Generation Future X/Pathfinder Vehicles. Specific emphasis will be on technologies integration and the issues which impact the system level operation. Examples are propulsion integration, TPS, tankage and pressurization, guidance and control. In addition, interaction with ground support systems will be addressed. On the X-37 Program he will work closely with vehicle and propulsion design and development personnel in redefining elements of the Program and resolution of technical issues. (Mod 11, 15)

Task Results

Summary:

The X-37 vehicle is a technology demonstrator sponsored by NASA. It includes a number of experiments both imbedded (i.e. essential aspects of the vehicle) and separate. The technologies demonstrated will be useful in future operational versions as well as having broad applications to other programs. In the longer view, X-37 is intended to demonstrate the capability of an orbiting vehicle with substantial propulsion capability to perform missions both for NASA and USAF. X-37 will be placed in orbit by some launch vehicle (some candidate vehicles require expenditure of some X-37 propellant) and will use the majority of its onboard propellant for orbital operations. The Space Shuttle is the chosen launcher for the first two missions. This will deliver X-37 to orbit with a full propellant load. The X-37 is a winged vehicle with a "butterfly" tail. As far back as the wing trailing edges, the planform is similar to the Space Shuttle Orbiter but the fuselage extends further aft and mounts the two ruddervators that are the tail surfaces. This configuration is more stable at high angle of attack than delta configurations such as Shuttle or X-33. These latter vehicles tend to run away in pitch above a certain high angle of attack, meaning a risk of flipping over. In the X-37 configuration, the tail surfaces come out of the wing shadow as angle of attack increases resulting in a pitch down tendency.

Mr. James R. French, of JRF Engineering Services and as a consultant to SAIC, has provided technical support to the X-37 NASA Program Office since the beginning of the program. In providing this service, Mr. French has maintained close contact with the Boeing Seal Beach and Rocketdyne technical teams via telephone, e-mail, and periodic visits. His interfaces were primarily with the working engineers in order to provide NASA sponsors with a different view than that achieved through management channels.

Mr. French's periodic and highly detailed technical reports were submitted to NASA and SAIC on a weekly/monthly basis. These reports addressed a wide spectrum of programmatic and technical interests related to the X-37 Program including vehicle design, flight sciences, propulsion, thermal protection, Guidance Navigation & Control (GN&C), structures, and operations. During Option Year 1 (10/1/99 – 9/30/00), of Contract NAS8-99060, Mr. French's reports were provided directly to sponsoring and management personnel at NASA and SAIC. While this was also the case for Option Year 2 (10/1/00 – 9/30/01) of the contract, excerpts from Option Year 2 reports were also included in the Monthly Progress Reports (MPRs) that were provided to NASA by SAIC in context with Contract NAS8-99060. Key items thus reported are listed below for the Option Year 2 period of this contract.

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- Acoustic loads still too severe. Solution not clear. Consensus requirement for this vehicle is FO/FO/FS. Wind tunnel tests continue. Change request to beef up rudder not yet approved. Procedures and documentation for the Shuttle interface will require major manpower. Commented on Ground Operations. (JRF, 11-24-00)
- Vehicle weight is slightly above 6400 lbs., including 500 lbs. payload weight. Rocketdyne is fabricating hardware and preparing to assemble the Qualification engine. Wind tunnel tests continue essentially on schedule. Change request to beef up the ruddervator attach structure has been submitted but not yet approved. (JRF, 12/22/00)
- Boeing is considering several weight reduction approaches for the X-37. The limitations on weight are on planform loading and landing gear capability. The use of 6061 aluminum is being considered for the RCS tank. Rocketdyne is completing assembly of the turbopump. (JRF, 1/19/01)
- Recommended that eliminating the B-52 flights of the X-37 in favor of alternate approaches be evaluated. Discovered that a required change to the thruster valves of the X-37 had not been made. Repair work continues on the lower fuselage section of the X-37, in the areas that experienced core collapse. The currently catalogued potential weight increases and decreases are about equal, but this does not include the impact of the cable weight underestimate reported earlier. The CFD for RCS testing correlates well with the wind tunnel data. (JRF, 2/16/01)
- Recommendation made to evaluate elimination of B-52 flights for X-37 testing in favor of alternate approaches. The decision to retain the MPS is believed to be a good one. Boeing X-37 propulsion people have been provided contracts in the Air Force USFE program. A Weights Tiger Team is looking at ways to reduce vehicle weight. Work continues on repair of lower fuselage. The choice of launch vehicles is still in debate. (JRF, 3/16/01)

- Design work on the X-37 by Boeing has basically ground to a halt during the past two weeks due to NRA 8-30 proposal activity. With the probability of changing to an ELV launch from Shuttle, the vehicle will probably become much lighter as various Shuttle-edicted redundancies and other hardware is removed. A Rough Order of Magnitude (ROM) estimate is being prepared for cost and schedule to resume a full-scale composite tank effort. (JRF, 4/13/01)
- Reviewed the X-37 software validation and verification information from the Technical Interchange Meeting at Boeing Seal Beach on April 3-5. Provided consultation and technical insights in areas related to GN&C, propulsion, structures and materials, vehicle design and flight sciences. (JRF, 4.1.2.2)
- Paperwork is being initiated to change the X-37 fuel tank from composite to aluminum. Weight is holding reasonably steady for the moment. The decision on the program and hardware changes proposed in NRA 8-30 will be very critical. Resolution of the discrepancy between wind tunnels and CFD is progressing. (JRF, 6/8/01)
- With the word now out that X-37 will receive no funding from NRA8-30, the work at Boeing was cut back to about 65% of the former level. The weight of the orbital vehicle continues to hold steady. Work presently is being concentrated on the B-52 drop test vehicle. Some X-37 TPS test specimens based upon both 1K and 3K tows are being machined and tested at LaRC. Work on the high temperature TPS has stopped, however. Analysis tools and data pertaining to the natural frequency of the X-37 on the B-52 pylon have been provided to DFRC. X-37 wind tunnel entry planned for this summer will go ahead but will concentrate on low speed work. Work continues on low speed aerodynamics in support of the ALTV. Propulsion and electronics/software work is almost entirely on hold. (JRF, 7/6/01)
- Most of the X-37 activity at Boeing has been directed toward preparation for a major review by the Aerospace Corporation. This review will presumably play a significant role in the decision by USAF as to whether they will pick up a greater portion of the cost of the X-37 program. The fuselage structure is scheduled for delivery on 22 August. This fuselage is only suitable for ALTV use. Many of the weight saving and other modifications intended to be performed if it was to be used for orbital missions were not incorporated. The wing structure is expected to be completed in about a month. (JRF, 8/3/01)
- Concerning the X-37 propulsion trade studies, the number of options is being steadily reduced. It was decided that there was no particular point in carrying the baseline bipropellant to do DRM-1 since the monopropellant systems can do it handily. To keep the number of options under control, the options for DRM-1 are being reduced to those that are capable of meeting the DRM requirements but do not have a huge excess of performance. Similarly, for DRM-2 the team is trying to eliminate options that, by inspection, cannot meet the DRM and also those that, while they meet the requirement are less desirable because of excess complexity or some other reason. As a result, DRM-1 options are pretty much reduced to peroxide or hydrazine monopropellant options. The DRM-2 options are primarily bipropellant although the hydrazine monopropellant is an option. This points up the disparity in performance of 90% peroxide versus hydrazine as a monopropellant. The case for peroxide gets better with a higher proof but it will never be quite as good a monopropellant as

hydrazine. The various storable options involve bipropellant RCS or hydrazine monopropellant RCS. Both hydrazine and MMH are considered for the MPS. There is a tendency to favor the system using hydrazine in the MPS and monopropellant hydrazine thrusters as the simplest approach. As work continued on the X-37 propulsion trade studies, three options were carried for each DRM. In both cases, the peroxide baseline (using the AR2-3) is included, referred to as H-1, is included. For DRM-1 the other two are H-3A: a multiple RCS tank H_2O_2 system and S-3A: a single tank N_2H_4 system. For DRM-2, the other two are S-2B: an N_2H_4 /NTO bipropellant system with N_2H_4 monopropellant RCS and S-3B: a multiple tank N_2H_4 monopropellant system. (8/31/01)

Reports/Deliverables:

Weekly and Monthly Progress Reports from JRF Engineering Services to NASA and SAIC.

Technical Report: "Support to X-37 Program" (WBS 4.1.2.2, Future X/Pathfinder Technologies, X-37), September 30, 2000.

Technical Report: "Final Report, Support to X-37 Program" (WBS 4.1.2.2, Pathfinder Technologies Specialist, X-37), September 30, 2001.

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.2 Technology Evaluation and Analysis

4.1.2.3 Fastrac (MC-1) SRD, Engine, Engine Components Verification

Statement of Work

The contractor will provide qualified, expert personnel with extensive experience in the appropriate disciplines to perform engineering evaluations, validation and verification, and analyses of concepts, systems related technologies, and programs. A final report showing all data, models, and assessments will be written after consultation with appropriate NASA personnel. The elements of this document are Subsystems & Requirements, Internal and External Diagrams, Specifications & Requirements Mapping, Historical Comparisons & Testing, and Knowledge Consultation. (Mod 7) Provide assistance in updating and maintaining the Fastrac Engine Specification database and Fastrac Engine Component specifications database. Provide assistance in evaluating proposed development, verification and certification test planning documentation. Determine impact on the current engine database and component specifications database. Evaluate approved Engine CDR RIDs and engine/component requirement flowdown assessment to determine impact on the current engine and engine component specifications and associated databases. (Mod 14) Continue update and maintenance of the System Requirements Document (SRD) database, MC-1 Engine Specification database, and the MC-1 Engine Component Specification databases. (Mod 15)

Task Results

Summary:

During the March-June, 2000 timeframe, SAIC developed and processed four Fastrac Engine Verification Compliance Reports (VCRs) for closeout. After ensuring that each one was complete, including supporting documentation, they were submitted to the Fastrac Engine Product Development Team (PDT) Lead and Chief Engineer for approval. SAIC prepared four Verification Compliance Data Packs, and provided copies of the approved Systems Requirements Document (SRD) to the SRD Verification Engineer. SAIC continuously maintained and updated Fastrac and Component Verification Databases.

During the June-September, 2000 period, SAIC provided assistance in evaluating proposed development, verification and certification test planning documentation. SAIC also evaluated approved Engine CDR RIDs and engine/component requirement flowdown assessment to determine impact on the current engine and engine component specifications and associated databases.

With the termination of the MC-1 program, SAIC submitted the deliverable, "Engine Specification and Database". This document represented the final deliverable on this task. All of the databases and specifications maintained by SAIC have been archived at MSFC as part of the program closeout.

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Working to determine which Fastrac engine requirements can be verified via the baselined specification. Developed a Compliance Contact Assignment/Status Matrix to identify engine specification data. Manned offices in MSFC Building 4203. (1/21/00)
- Continued update of Fastrac engine description, verification, certification, design certification review, and acceptance sections of Verification/Certification Plan. (2/18/00)
- Completed recommendations for updates to the 60K Fastrac Engine Verification/Certification Plan. Prepared a Specification Change Notice (SCN) to update the engine requirements and verification section of SPEC 2675A. (3/17/00)
- Completed flow down of requirements from the X-34 Interface Control Document, Systems Requirements Document, and Structural Loads and Environments Addendum to the Fastrac Engine Specification. Assisted in preparation of Injector and Turbopump specifications for submittal to the Level V Board. (4/14/00)
- Prepared and submitted Fastrac engine specification to the Level V CCB. The SCN was approved with minor change. Completed work on requirement flow-downs from the ICD, SRD, SLED, and engine/components specifications. (5/12/00)
- Prepared and submitted the Fastrac 60K Engine specification to the Level IV CCB. Incorporated Level V CCB directed change and submitted the ECR/SCN for approval. Completed work on flow down of requirements from the X-34 ICD, SRD, and SLED. Completed flow down to the component specifications. (6/9/00)
- Prepared and submitted MC-1 (Fastrac) Engine specification SCN-2 to the Level III/IV CCB. Approved with minor changes. Rev B of MSFC-SPEC-2675 has been released to the Repository. New employee, Billy Gonterman, is on board to work the MC-1 Component specification updates. (7/7/00)
- Prepared/submitted MC-1 Engine specification SCN-3 to the Screening Board. Conducted a tabletop review of comments to SCN-3. Incorporating them into the revision. Reviewed requirements for flow-down from SRD, ICD, & SLED. Accomplished review/completion of MC-1 Nozzle and Gas Generator Specifications. Reviewed MC-1 Lines & Ducts Specification in a "Round Table" forum. (8/4/00)
- Presented the MC-1 Engine Specification SCN-3 to the Level IV Configuration Control Board (CCB). The SCN was approved as written. Conducted a preliminary review and assessment of OSC design safety requirements for the X-34. (9/1/00)
- Revision C to the MC-1 Engine Specification and associated requirements database was prepared and formally released. Reviewed/assessed OSC design safety requirements for X-34 that could impact the MC-1 design. Completed specifications for MC-1 injector and all ten valves. (9/29/00)

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- SCN-4 & MC-1 Engine Specification is nearing completion. Revising scripts and reports for engine database to ensure identical formats for MSFC & SAIC. (10/27/00)

- The recently submitted MC-1 Engine Specification resolves all remaining requirement flow-down issues to date, and incorporates additional program changes. The Nozzle Specification was completed, approved, and released to the MSFC Repository. The Main Injector and Gas Generator specifications were accepted and have been submitted to the CCB for approval. (11/24/00)
- Screening Group comments to SCN-4 to the MC-1 Engine Specification have been received and are being incorporated into the SCN. The MC-1 Engine and Component Verification/Certification Plan is being revised to incorporate changes. (1/19/01)
- The Level IV CCB approved SCN-4 to the MC-1 Engine Specification. Approved changes have been incorporated into the specification, and Revision D has been released to the Repository. Billy Gonterman, SAIC, traveled to SSC to perform a five-day readiness assessment on the progress of facilities activation. Implemented modifications to the MC-1 Engine TPA Component Database. (2/16/01)
- Participated in development of the Requirements and Verification Team presentation at the MC-1 Quarterly Review on February 26, 2001. Cancellation of the X-34 project was announced on March 1, 2001. (3/16/01)
- Supported the MC-1 Team in completing and archiving all relevant data as part of the program closeout phase scheduled to run through April, 2001. The MC-1 Engine Turbopump Specification was completed/accepted. (4/13/01)

Reports/Deliverables:

Technical Report: "Fastrac Engine Verification" (Including Verification Compliance Reports, Engine & Component Verification Compliance Data Packs, and Databases), June 6, 2000.

Technical Report: "Fastrac Engine Verification" (Engine Specification Database), September 30, 2000.

Technical Report: "MC-1 SRD, Engine, and Engine Components Verification Engineering" (MC-1 Engine Specification, MSFC-SPEC-2575D), April 9, 2001.

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.2 Technology Evaluation and Analysis

4.1.2.4 RFS Technologies Specialist

Statement of Work

The contractor will provide qualified, expert personnel with extensive experience in the appropriate disciplines to perform engineering evaluations, validation and verification, and analyses of concepts, systems related technologies, and programs. A final report showing all data, models, and assessments will be written after consultation with appropriate NASA personnel. The elements of this document are Subsystems & Requirements, Internal and External Diagrams, Specifications & Requirements Mapping, Historical Comparisons & Testing, and Knowledge Consultation. (Mod 7)

Task Results

Summary:

Mr. Pete Mitchell, a consultant to SAIC provided technical support to the Reusable Flyback Stage (RFS) activity at NASA/MSFC. This work was effected under WBS 4.1.2. The task was concluded by Mr. P. Mitchell and documented in the report cited below under "Reports/Deliverables". A second phase of activity was contemplated but was not implemented.

Reports/Deliverables:

Technical Report: "RFS Jet Engine Assessment Report" (WBS 4.1.2, Technology Evaluation and Analysis), June 30, 1999

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.2 Technology Evaluation and Analysis

4.1.2.5 Future X/Pathfinder Technologies Specialist (X-34) (*Jim French*)

Statement of Work

The contractor will provide qualified, expert personnel with extensive experience in the appropriate disciplines to perform engineering evaluations, validation and verification, and analyses of concepts, systems related technologies, and programs. A final report showing all data, models, and assessments will be written after consultation with appropriate NASA personnel. The elements of this document are Subsystems & Requirements, Internal and External Diagrams, Specifications & Requirements Mapping, Historical Comparisons & Testing, and Knowledge Consultation. (Mod 7) Mr. Jim French, of JRF Engineering Services, a consultant to SAIC, will provide system design and engineering support to the Future X/Pathfinder activity. He will assist with issues of overall system design, test, and operation. New effort on this task will be to provide support to the NASA MSFC X-34 Program Office for testing of the X-34 vehicle. (Mod 11) The tests shall include static testing of the X-34 main propulsion system and flight of the X-34 vehicle. (Mod 15)

Task Results

Summary:

Under Contract WBS 4.1.2.5 of NAS8-99060, WBS 4.1.2.5, SAIC provided to NASA/MSFC the subcontracted consultative services of Mr. James R French of JRF Engineering Services for the purpose of providing system design and engineering support to the Future-X/Pathfinder activity. In this context, Mr. French addressed issues of overall system design, test, and operation. Effort on this task included support to the NASA MSFC X-34 Program Office for testing at the White Sands Missile Range, and static testing of the X-34 main propulsion system and unpowered flight of the X-34 vehicle.

With his extensive experience, Mr. French provided engineering evaluations, validation and verification, analyses of concepts, and technologies assessment related to the X-34 Program. In providing this service, Mr. French supported meetings at NASA and the X-34 contractor sites, either in person or by telecon. Informal reports were submitted weekly to SAIC and were incorporated into the monthly reports required by the contract.

When Mr. French joined the program, the vehicle propulsion system test was planned for the Horizontal Test Facility at Holloman AFB. This facility, originally used to test motors for the nearby rocket sled track, had been unused for many years. With the advent of program restructuring, the location of the testing was opened. In addition to the HAFB facility, the NASA White Sands Test Facility became a candidate. At the request of NASA, Mr. French carried out a detailed technical comparison of the two candidate test sites. Mr. French concluded that the two sites rated very close in technical capability, but each had distinctly

different strengths and weaknesses. In supporting this effort, Mr. French maintained contact with personnel at HAFB and WSTF as well as the NASA program office.

During Option Year 1 (10/1/99 – 9/30/00) of Contract NAS8-99060, Mr. French's reports were provided directly to sponsoring and management personnel at NASA and SAIC. While this was also the case for Option Year 2 (10/1/00 – 9/30/01) of the contract, excerpts from the Option Year 2 reports were also included in the Monthly Progress Reports (MPRs) that were provided to NASA by SAIC in context with Contract NAS8-99060. Key items thus reported are listed below for the Option Year 2 period of this contract.

On March 5, 2001, Mr. French received indication from the X-34 Program Office that, due to cancellation of the X-34 Program, his services were no longer required. The contracted support to the program on this task had thus been fulfilled and there was no remaining work to be performed.

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- Leaky valves delayed final test of MC-1 Engine #5. The cause is being investigated. Leak checks at higher pressure will be made. Preparations were made for various meetings. (11/24/00)
- WSTF has finished a first cut at the Facility Requirements Document (FRD) and has presented the FRD to their facility design people who are now working on cost estimates. The 12/4/00 MC-1 engine test appeared to be successful. (12/22/00)
- WSTF has finished a first cut at the X-34 Facility Requirements Document. The facility design people are working on cost estimates. The document contains a number of TBD items. (1/19/01)
- Pathfinder Technologies Specialist support for the X-34 program has been stopped and a final report submitted consisting of electronic and hard copies of the work to date. (4/13/01)

Reports/Deliverables:

Weekly and Monthly Progress Reports from JRF Engineering Services to NASA and SAIC.

Technical Report: "Support to X-34 Program" (WBS 4.1.2.5, Future X/Pathfinder Technologies, X-34), September 30, 2000.

Technical Report: "Final Report, Pathfinder Technologies Specialist, X-34" (WBS 4.1.2.5, Pathfinder Technologies Specialist, X-34), April 2, 2001.

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.2 Technology Evaluation and Analysis

4.1.2.6 Combined Cycle Propulsion Database (CCPD)

Statement of Work

The contractor will provide project management, technical expertise and any other services required to accomplish the development of a web based CCPD, including the delivery of a working version to NASA for server implementation. The contractor shall perform the necessary documentation collection, document synopsis, storage, database processing, and all services necessary for making a CCPD data entry. The Contractor shall continue to improve the design, make appropriate changes and upgrades, and maintain the CCPD during its expanded development. (Mod 7, 15)

A **Phase III effort (CCPD-III)** shall be carried out by the contractor that emphasizes further population of the database with approximately 400 or more new documents and media material. This shall involve application of the requisite technical expertise for acquisition, evaluation, and rendition of the technical data, and shall include visits to selected data sources for the purpose of accessing and/or discussing CCP-related archival data. Minimal software development is expected in CCPD-III, and related efforts shall be placed on simply maintaining the application and performing administrative functions, including the addition of new users and data uploads to other Space Transportation Directorate tools (i.e., STIN). (Mod 18)

Task Results

Summary:

Work on the Combined Cycle Propulsion Database (CCPD) was initiated under WBS 4.1.2 during the contract period preceding October 1, 2000. This effort is referred to as Phase I of the CCPD and was reported in the contract Monthly Progress Reports as evidenced by some of the Key Items noted in the following section. The Phase I activity focused on the design and establishment of the CCPD, and its population with some 200+ pertinent documents. As covered in the Phase 1 final report (Referenced below), the initial SAIC contracted effort covered three accomplishment areas. These were (1) development of the core software web-compatible application, (2) establishment of the data handling processes, and (3) initial population of the CCPD with high-priority documents...206 of them, with full descriptive information.

Phase II of the CCPD was continued under this WBS (4.1.2.6) over the period October 1, 2000 to March 31, 2001. Governed by a reduction in funding to be made available for continuing the CCPD development effort beyond Phase 1, it was decided to halve the period of performance to a six-month effort, rather than a full-year activity. This was done to elevate the level of effort which SAIC could apply to the project on a sustaining basis. The resulting effort was then mainly directed to the processing of in-hand documents into the database.

Phase III, or CCPD-III, was carried out by SAIC with emphasis on further population of the database resulting in over 400 new documents and media material. Minimal software development was required in CCPD-III, and related efforts were placed on maintaining the application and performing administrative functions, including the addition of new users and data uploads to other Space Transportation Directorate tools (i.e., STIN).

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Installed the CCPD Search engine and began the process of configuration. Developed several alternative means of displaying summary level data. Completed ERJ tutorial. Created secure folder to allow viewing privileges to only the data team. Conducted literature search on NASA database to identify available Marquardt documents. Developed second tier data processing flow diagrams. Developed an Excel spreadsheet to review areas of coverage by current and additional documents (3/17/00)
- Completed "Declassification Marking Review" sheets for the first seven volumes of NAS7-377 in preparation for issuance of a new CD-ROM for the Combined-Cycle Propulsion Database (CCPD). Selected 100 documents from Mr. R. Foster's personal library to be shipped to SAIC for further down-selection/scanning. Completed new CCPD file and reviewed CCPD brochure for "Turning Goals into Reality" event. (5/12/00)
- Studied quick view parameters for possible inclusion in the Combined Cycle Propulsion Database (CCPD). Developed a CCPD brochure for the TGIR and TABES conferences. Reinitiated contacts with SAIC intellectual property personnel in order to follow up on Boeing and Kaiser Marquardt agreements. Evaluating contents of Pennsylvania State Propulsion Engineering Research Center (PERC) Symposiums from the past for possible CCP-related documents. (6/9/00)
- Constructed a CCPD document summary spreadsheet that included a "grade" for the quality of each document and specific comments as to problems and recommended solutions. Evaluated the general accuracy of the Optical Character Recognition (OCR) process on a variety of document qualities. Evaluated current "word search" capability within the CCPD under a number of scenarios. (7/7/00)
- Completed adding CCP images and histories for the Timeline. Installed RealServer on the web server to facilitate the streaming of video/audio via the web. Captured Czysz and Billig clips from the 1998 Tutorial Program. (9/1/00)

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- Identified additional fields in the CCPD database for use as search criteria. Added the Windjammer video to the tutorial section. Added document type listing. (10/27/00)
- Performed thorough testing on the Combined Cycle Propulsion Database (CCPD) website. Modified the ERJ tutorial to display in rocket mode. Made modifications to the data searches/results. Reworked the search screen layouts and added validation to the date range fields. (11/24/00)

- As of 12/19/00, 93 of the 173 Wright Patterson documents have been fully processed and loaded into the CCPD, bringing the total document count to 299. Six new NASA users were given access to CCPD, bringing the total to twelve. (12/22/00)
- Developed a Document Tracking System (DTS) that documents each entry into the CCPD. Reviewed all documents in the database. Acquired ~50 additional documents to be scanned and entered into the CCPD. (1/19/01)
- Replaced 25 Combined-Cycle Propulsion Database (CCPD) documents; modified the low-on screen to include a direct email link for user contact; prepared a summary presentation of current and proposed tasks. (2/16/01)
- Phase II work on the CCPD was concluded and a report was submitted which graphically summarizes the status of the extensive and continuing database development that was accomplished in CCPD-II. A demo will follow. (4/13/01)
- Initiated an effort to search for relevant documents from the LaRC technical server. Identified some 100 documents already in pdf form. Reviewed all documents already in the CCPD that were identified to have Proprietary, Completion Sensitive, Limited Rights, or Company Private markings. Based on this review, the database was cleared for access beyond Government personnel. Following coordination with MSFC, access was then granted to users representing Commercial and Academic entities. (5/11/01)
- A second report-gathering trip was taken to the Dayton, Ohio area on 14-16 May. It included visits to WPAFB and to Robert F. Cooper's private document collection. Numerous new documents related to the subject of Combined Cycle Propulsion were gathered. It is conservatively estimated that this "batch" of documents will yield 100 additional documents. A "kickoff" meeting was held with Media Fusion to discuss the efforts under their subcontract to improve the appearance and functionality of the CCP website. (6/8/01)
- CCPD-related documents borrowed from the Air Force's High Speed Propulsion Technical Resource at WPAFB and Bob Cooper's personal library, both located at Dayton, Ohio, were scanned, OCR'd and reviewed this month. Documents were returned to Dayton during the week of June 23rd. (7/6/01)
- Special efforts were made to develop and implement "User Friendly" starting places for document retrieval. A collection of multi-volume sets of documents have been grouped and linked together. This new feature had been designed and is ready for implementation. The CCPD "facelift" by Media Fusion was successfully implemented. These new "pages" will greatly enhance general appearance and navigability of the website. (8/3/01)
- Some 70 NASP program published reports with propulsion system and technologies relevance were selected from a larger list in hand. Assistance in obtaining these documents was requested of the NASA-Langley *Hyper-X* program office. (8/31/01)

Reports/Deliverables:

Technical Report: "Combined-Cycle Propulsion Database (CCPD)", (WBS 4.1.2/4.1.2.7, Technology Evaluation and Analysis), September 30, 2000.

Demonstration: Phase III "CCPD Demonstration," August 2001.

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.2 Technology Evaluation and Analysis

4.1.2.7 Development of a Software Tool for the Rapid Evaluation of Multi-Stage Reusable Launch Vehicles (DESE)

Statement of Work

The contractor shall develop a software tool to rapidly make first order evaluations of multi-stage launch vehicles that have a variety of fully or partially reusable configurations including conventional series staging configurations and configurations with parallel burn and propellant cross feed. The tool will provide NASA with a flexible quick-look rocket equation based computation engine and the ability to evaluate relatively simple scenarios on integrated ascents to Earth orbit.

Task Results

Summary:

In partnership with SAIC, DESE developed a software tool to rapidly make first order evaluations of multi-stage launch vehicles. This program is applicable to a variety of fully or partially reusable configurations including conventional series staging configurations and configurations with parallel burn and propellant cross feed. The tool provides NASA with a flexible quick-look rocket equation based computation engine and the ability to evaluate relatively simple scenarios on integrated ascents to Earth orbit.

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- Under subcontract to SAIC, DESE has completed the Launch Vehicle Evaluation code for their task, "Software Tool for Rapid Evaluation of Multi-Stage RLV's." The software has been installed and checked out at the NSSTC, per NASA's request. (3/16/01)

Reports/Deliverables:

Computer Code, "Software Tool for Rapid Evaluation of Multi-Stage RLV's", March, 2001

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.6 Space Transportation Resources (STR) Database

Statement of Work

The contractor will continue development and enhancement of the STR database that will allow NASA and industry to access past and present Space Transportation resources and technologies including international systems *and specialized launch vehicle outputs. (Mod 7)* As development of the database continues it will provide an up-to-date centralized source for technical data for use in; assessing the historical and current state of space transportation resources and supporting technology, performing trade studies and analyses, and planning for future technology. An initial and final report comprised of DB Requirements Refinement, DB Availability on Web-Server, Resources Database Updates, DB Capabilities Development/Implementation will be delivered.

Task Results

Summary:

SAIC developed the Space Transportation Resources (STR) Database for the Advanced Space Transportation Program at NASA Marshall Space Flight Center. The STR Database contains descriptions of launch vehicles, past, present and in development, as well as numerous design study concepts. This database provides government, commercial and educational organizations a resource for space launch vehicle data. System information, such as capabilities, manufacturer, dimensions and cost, is provided for each vehicle. The STR Database CD-ROM contains:

- Data on over 350 launch vehicles
- Numeric data (weights, cost, etc.)
- Textural data (vehicle description, manufacturer, etc.)
- Multimedia inputs
- Photographic images
- Video documentation
- Other graphics (sketches, artists concepts)
- Glossary – over 200 references
- Capability to perform various data searches and range of value routines
- Data available in both English and metric units
- Multimedia enhancements for the STR web site

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Implemented changes to the STR Database resulting from meetings with MSFC. (4/2/99)

- Incorporated the STR Database into a Macintosh/PC "stand-alone" CD-ROM, via "FileMaker Pro. Internal (SAIC) checkout is in progress. Beta version to follow. (4/30/99)
- Provided copy of updated STR CD-ROM to NASA for preview prior to next release. Using FileMaker Pro, incorporated Macintosh & PC capability into this stand-alone CD. (5/28/99)
- Data from more than 20 international vehicles have been entered and will be soon be available on the Web version. We will update the CD-ROM after the Web is complete. We've also made contact with the Space Propulsion Synergy Team (SPST) to elicit data inputs. (6/25/99)
- STR Database "SMART" form iterated several times with resultant improvement in data loading efficiency. Data for 40+ international vehicles compiled/verified. (7/23/99)
- A major update to the information available on the STR database web site was completed with the release of data on international launch vehicles. (8/20/99)
- Moving forward with plan to provide STR Database spreadsheet data listings to the vehicle developers for their review, critique, and feedback on missing data. (9/30/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Reviewed all data recently added to the STR database. Formulated plans to continue into the next phase development. Checked data displays for consistency. (10/29/00)
- Continued review of data inputs to the Space Transportation Resources (STR) database, including the multi-media portions of the database. Preparing latest STR update. (11/26/99)
- Reviewed the multi-media portions of the STR database to insure all videos, films, and photos apply to the proper vehicles. Corrected discrepancies. Made deletions. (12/24/99)
- Developing STR Database data inputs to describe the mid-60s NOVA studies. Input data to the STR Database that describe fifty-five concepts developed during the NOVA launch vehicle studies in the mid-to-late 60s. After update completion, new CDs will be created and distributed to persons who have previously received a CD. (3/17/00)
- Utilizing a recently discovered source of launch history data to develop a history of vehicle successes and failures. Expect this to be of value to the STR Database. (4/14/00)
- Demonstrated STR Database at the joint NRO/AIAA Workshop on 2-4 May. (5/12/00)
- Demonstrated the Space Technology Resources (STR) Database at the TGIR conference at MSFC and at the TABES conference at the VBC in Huntsville. (6/9/00)
- Received favorable comments from attendees at the TGIR and TABES symposia where we demonstrated the Space Transportation Resources (STR) database. (7/7/00)

- Completed the update of launch histories based on the Launch Log recently discovered on the Internet. All Russian and U.S. vehicles have been updated. (8/4/00)
- STR Internet capability is in place. Reviews of the documentation are in the final phases. Discussed possible improvements with MSFC Pathfinder personnel. (9/1/00)
- STR Database deliverables have been completed, including Internet capability and delivery of a manual describing the various displays and navigation features. (9/29/00)

Reports/Deliverables:

Technical Demonstration, "Data Population & Operational Software", September 30, 1999.

Technical Report, "Data Population and Operational Software Demonstration", (WBS 4.1.6, STR Database), September 30, 2000.

4.0 Integrated Design & Engineering Technologies

4.1 Integrated Design and Engineering

4.1.7 Pathfinder Launch Vehicle Design Characteristics and Graphics Development

Statement of Work

Utilizing the existing Space Transportation Resources (STR) database as a starting point, the contractor shall expand and improve the capabilities for access to a database of launch vehicle design characteristics. The first phase, of six months duration, will be focused on defining requirements related to the intended audience, i.e., parameters to be included, scope of vehicle coverage, capabilities to be available to users, and development of displays, queries, and reporting formats. The contractor shall be responsible for providing overall engineering coordination, defining content, and data acquisition and verification.

The contractor shall also be responsible for modifying the database infrastructure and the interface routines and user navigation aids to provide improved technical illustration, graphic design, computer imaging and multimedia programming to support tasks related to the Database. Taking advantage of emerging technological improvements, the design and development of graphics and programming to provide database access in a CD-ROM format, including the display screens to view the vehicle parameters and illustrate input/output format requirements shall also be modified. If required, computer renderings and image depictions, based on engineering and/or artistic views, shall be developed for the appropriate vehicle systems. Provisions to enable development of an Internet accessible version in future phases shall also be included. (Mod 15)

Task Results

Summary:

As the Mid-Term deliverable, Media Fusion, under subcontract to SAIC, provided a document that outlined the content structure for the final deliverable. The final deliverable was a CD-ROM product that was developed by Media Fusion and subsequently demonstrated and delivered to NASA/MSFC Program Office personnel. This product reflected the requirements of the above Statement of Work.

Key Items Reported in Monthly Progress Reports (Option Year 2, 10/1/00 – 9/30/01):

- On the Pathfinder Launch Vehicle Characteristics & Graphics Development effort, work to date had concentrated on understanding concepts and previous work. Nearly all of the previously accumulated launch vehicle characteristics are usable. (10/27/00)
- SAIC/Media Fusion efforts continue on a CD-ROM for "Pathfinder Launch Vehicles Characteristics and Graphics Development". The database structure will be hierarchical and will be classified per vehicle performance/availability status. (11/24/00)

- Under subcontract to SAIC, Media Fusion has completed the major portion of the architecture for their task, "Pathfinder Launch Vehicle Design Characteristics and Graphics Development. (3/16/01)
- The major portion of the architecture on the "Pathfinder Launch Vehicle Design and Graphics Development" task is complete. Following a planned status review at MSFC in the near future, this work will be concluded. (4/13/01)

Reports/Deliverables:

Technical Report, "Pathfinder Launch Vehicle Design Characteristics and Graphics Development (Mid-Term)", December 29, 2000.

Prototypical Electronic Database and CD-ROM Master, (WBS 4.1.7, Pathfinder Launch Vehicle Design Characteristics and Graphics Development), March 31, 2001.

4.0 Integrated Design & Engineering Technologies

4.2 Systems Visualization

4.2.1 X-33 Flight Coverage

Statement of Work

The contractor will use its extensive digital database of technical information related to Reusable Launch Vehicle (RLV) Technology Program subjects to provide highly detailed digital models of selected RLV technologies for use as reference documentation, press release, and actual flight coverage. The contractor will integrate dynamic video representations of X-33/RLV ground/flight video scenes, very high-resolution terrain data, and photographs into dynamic video representations of the checkout, launch, overland trajectory, approach and landing, and ground operations for the planned flights of the X-33/RLV. Develop requirements for visualization of the X-33 flight and hardware/software interfaces with the Dryden Flight Research Center (DRFC) telemetry network. (Mod 7) Full-length video visualizations of the X-33/RLV flight will continue to be developed.

Within the subject work package the above work will be expanded to provide near real-time X-33/RLV flight coverage visualizations of the actual test flights of the X-33/RLV by using downlinked telemetry data from NASA and/or Lockheed Martin for public access to the test flights and recovery, and for possible situational awareness visualizations. Deliverables will consist of status report summaries of each sub-task at six-month reporting intervals, and a final report.

Task Results

Summary:

SAIC's X-33 Flight Visualization task, initiated in early 1998, was to develop integrated visualizations of the X-33 flights via digital high-resolution videos, programmatic films and website formats for public and programmatic information and outreach. Continuing efforts in cooperation with NASA Public Affairs were focused on providing a capability for flight coverage of the actual X-33 test flights. Television flight coverage was to be accomplished via real-time visualization based on the telemetry data stream from the vehicle as it flies from its launch site to its designated landing site several hundred miles downrange.

The initial flight visualizations for SAIC's "Public and Programmatic Information and Outreach" task were based on flight profile data provided to SAIC by NASA. Later, during the actual flights, the vehicle data stream information was to be acquired by NASA/Dryden as an integral part of the flight control activity. This data stream would also be simultaneously available to SAIC participants at Dryden for input to the "X-33 Flight Coverage" visualization. Virtual Creations Incorporated also supported SAIC in both of these tasks by preparing the visualizations for public web-site presentation. The availability and use of the real time visualizations and web-site data would be determined and controlled by NASA Public Affairs prior to, and during, the X-33 flights.

SAIC created scenarios of the planned X-33 flights using a software package developed by Analytical Graphics, Incorporated (AGI), called Satellite Tool Kit, Visualization Option (STK/VO). The videos combine the X-33 vehicle images, launch/landing scenes, overflight terrain images, and trajectory/attitude data.

SAIC used a polygonized model of the X-33 vehicle derived from one developed by John Frassanito & Associates (JF&A) of Houston, Texas. JF&A also provided enhanced imagery of pre-flight launch and landing site scenes. The latter consisted of lifelike digital visualizations depicting key preparation, launch, landing, and turnaround operations. The visualizations were generated using ray-tracing techniques, and featured combinations of highly detailed vehicle models, aerial photographs, and actual ground support personnel. The ray-tracing rendering of the scenes consumed many hours, but produced visualizations with realistic glints, shadows, and diffuse reflections. In contrast, the STK/VO model could be run and manipulated in real time.

Under the earlier STIP Contract, an important component of NASA's early "Public Outreach" initiatives was an interactive Strategic Visualization display of a simulated X-33 flight. SAIC Designed and manned this display at the Experimental Aircraft Association (EAA) Air Venture, Oshkosh, in July 1998. This display was prominently located at the event and was the focus of extensive public interest. It featured a capability for public participation in simulated control of the X-33 flight via an interactive "joystick". With the majority of the outreach activities complete, the primary focus of the subject contract effort was shifted to supporting the coverage of the test flights. This single objective encompassed two parallel tasks: integrating SAIC's visualization hardware/software into the DFRC telemetry data network and developing the final visualization "looks" for public viewing and NASA TV commentary. The individual sub-tasks for this effort were to (1) identify and coordinate hardware/software interface requirements, (2) understand the X-33 telemetry network and the PC-Goal data format, (3) develop and checkout the interface software, (4) integrate the visualization hardware into the NASA TV network, and (5) participate in an end-to-end checkout of the NASA TV network.

Work on this task was directly tied to the Lockheed Martin Skunk Works (LMSW) development of the X-33 telemetry network and datastream content. In many instances, SAIC needed information regarding the network and datastream before LMSW was in position to comply with its requests. For this reason, the effort was focused exclusively on the first three subtasks. SAIC continued to coordinate requirements with LMSW and awaited a simulated X-33 datastream in order to move closer to the final objective of integrating the visualization into the telemetry network.

SAIC's ultimate requirements were to support the NASA Media Relations commentary and provide NASA TV with an analog signal of the X-33 flight visualization. The commentator requires a different visualization of the X-33 flight than that provided to NASA TV for public viewing. The commentator needs to view the flight from a constant perspective and have "talking points" incorporated with the visualization while NASA TV requires a view that changes to provide optimum visual representation of the X-33's flight in relation to its surroundings. Detailed discussions regarding interface to the PC-Goal telemetry data network at DFRC were provided in the report cited below entitled "STK/VO Integration".

The second subtask involved integration of high-resolution terrain data. Sections of high resolution terrain data for the launch and landing sites were obtained from JPL and incorporated in the initial visualization videos delivered in 1988. After completion of this early work, SAIC requested the remaining data from JPL. Several months were spent waiting on access and delivery of the data, but for the most part, the task progressed as needed. SAIC obtained the complete JPL Landsat mosaic for the southwestern United States in Digital Linear Tape (DLT) format. Working with CSC, the computer support contractor at MSFC, SAIC identified a workstation with a DLT drive and obtained access to the machine. Using this workstation and JPL utility programs SAIC extracted data for the areas needed from three of the six data bands contained in the JPL Landsat mosaic. SAIC then merged the bands into one file and added a header to each file to make them into portable pixel map (ppm) files.

SAIC's concluding task was to develop the final visualizations to support the commentator and NASA TV. SAIC completed a final review of the requirements with NASA Media Relations and was ready to initiate development of the final visualizations...until a "stop work until further notice" order was received.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Obtained a data tape from JPL containing the Landsat Mosaic of the Western United States for use in X-33 flight visualization. Coordinated X-33 to PC-GOAL interfaces with the Dryden Flight Research Center (DFRC). (3/5/99)
- Checked out and demonstrated X-33 interface software using a simulated data stream. (4/2/99)
- Continued evaluation of data rate and processor speed for X-33 Flight Coverage. Pursued issues related to location of X-33 visualization hardware at DFRC. (4/30/99)
- Continued work with tools needed to build S/W interfaces for X-33 flight coverage. (5/28/99)
- Demonstrated the "real-time" X-33 flight visualization via networked data. (7/23/99)
- Continued efforts to obtain information needed to complete the integrated checkout of the X-33 visualization hardware into the DFRC network. (8/20/99)

Key Items Reported in Monthly Progress Reports (Option Year 1, 10/1/99 – 9/30/00):

- Coordinated a technical interchange to finalize technical specifications/requirements involving the interface with the rest of the X-33 data exchange network. (10/29/99)
- Coordination efforts with MSFC Media Relations, DFRC, and LMSW have resulted in answers to a number of technical questions relating to SAIC support of X-33 Flight Coverage. We have obtained the remaining terrain data files required to show high-resolution terrain over the entire flight path from Edwards to Dugway. (11/26/99)
- Working with MSFC Media Relations, we established the capabilities that are expected for viewing in support of the MSFC commentator during X-33 flight. Our X-33 Flight Coverage task has been suspended until we receive instructions to resume. (12/24/99)

- Delivered X-33 reports, "STK/VO Integration" and "Narratives & Note Screens."
(1/21/00)

Reports/Deliverables:

Technical Report, "STK/VO Integration" (WBS 4.2.1, X-33 Flight Coverage),
December 31, 1999.

Technical Report, "Narratives and Note Screens" (WBS 4.2.1, X-33 Flight Coverage),
December 31, 1999.

4.0 Integrated Design & Engineering Technologies

4.2 Systems Visualization

4.2.3 John Frassanito & Associates (Subcontract)

Statement of Work

Develop and maintain a digital database of information relating to other Space Transportation Projects related to RLV technologies. From these data the contractor shall produce high-resolution visualization products of the Space Transportation elements that portray each of the concepts at effective levels of communication. Visualization products shall reflect technically accurate detail, graphics designations, and settings. Information will be updated on an on-going basis to reflect the status of each of the program elements. Visualization products will be posted on designated directories on servers located at JF&A, the contractor's server, and MSFC. Visualization products will be delivered on each sub-task. SAIC and JF&A will develop and produce system visualizations of the concepts and technologies required to support ASTP and Exploration Transportation efforts. (Mod 7)

Task Results

Summary:

Under subcontract to SAIC, John Frassanito & Associates (JF&A) developed and maintained digital databases of information related to RLV space transportation projects. From these data JF&A produced high-resolution visualization products of the Space Transportation elements that portrayed concepts at effective levels of communication. Visualization products reflected technically accurate detail, graphics designations, and settings. Information was updated on an on-going basis to reflect the status of each of the program elements. Visualization products were posted on designated directories on servers located at JF&A, the contractor's server, and MSFC. Visualization products were delivered on each sub-task. SAIC and JF&A developed and produced system visualizations of the concepts and technologies required to support ASTP and Exploration Transportation efforts.

Key Items Reported in Monthly Progress Reports (Base Year, 2/8/99 – 9/30/99):

- Transferred all drawings and files on Shuttle Crew Escape concepts to Steve Cook. Completed a video on a Chemical Transfer Stage, a SEP stage, and a Nuclear stage. (4/2/99)
- Delivered ASTP Visualizations to the MSFC Website. Additional stills and configurations in support of the Spaceliner 100 concepts were prepared and delivered. (4/30/99)
- X-33 Flight Visualization software testing is underway on a MaxVision computer. We are assessing problems with the data stream keeping up with STK in real-time mode. (6/25/99)
- Work with the Transportation Office by Frassanito and Associates included delivery of a "Solar Sail" video, and delivery of a CD-ROM documenting all previous efforts.

Considerable effort was expended in support of Code R to print/release the Annual Report for Code R. (7/23/99)

Reports/Deliverables:

Visualization products were placed on the MSFC website.

CONCLUDING COMMENTS

SAIC successfully addressed all of the tasks conveyed in Contract NAS8-99060 and satisfactorily met the expectations of the respective MSFC Task Leads. Forms DD250, "Materials Inspection and Receiving Report", were submitted and approved for each of the reports/deliverables required by the contract.

The Financial Reports for this contract were submitted every four weeks, under separate cover, per the same schedule as the Technical Monthly Progress Reports.

SAIC is pleased to have had the opportunity to support NASA/MSFC in this important contract activity.

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13. ABSTRACT (Maximum 200 Words) This document is the final report by the Science Applications International Corporation (SAIC) on contracted support provided to the National Aeronautics and Space Administration (NASA) under Contract NAS8-99060, "Space Transportation Systems Technologies". This contract, initiated by NASA's Marshall Space Flight Center (MSFC) on February 8, 1999, was focused on space systems technologies that directly support NASA's space flight goals. It was awarded as a Cost-Plus-Incentive-Fee (CPIF) contract to SAIC, following a competitive procurement via NASA Research Announcement, NRA 8-21. This NRA was specifically focused on tasks related to Reusable Launch Vehicles (RLVs). Through Task Area 3 (TA-3), "Other Related Technology" of this NRA contract, SAIC extensively supported the Space Transportation Directorate of MSFC in effectively directing, integrating, and setting its mission, operations, and safety priorities for future RLV-focused space flight. Following an initially contracted Base Year (February 8, 1999 through September 30, 1999), two option years were added to the contract. These were Option Year 1 (October 1, 1999 through September 30, 2000) and Option Year 2 (October 1, 2000 through September 30, 2001). This report overviews SAIC's accomplishments for the Base Year, Option Year 1, and Option Year 2, and summarizes the support provided by SAIC to the Space Transportation Directorate, NASA/MSFC.				
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